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Jameco Part Number 200660

Hard Drive Product Manual

DiamondMax™ 4320

91728D8, 91512D7, 91303D6
91080D5 90845D4, 90648D3
90432D2

DiamondMax™ 4320

91728D8, 91512D7, 91303D6, 91080D5
90845D4, 90648D3, 90432D2

Part #1407

Maxtor®

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Before You Begin

Thank you for your interest in the Maxtor DiamondMax™ 4320 AT hard disk drives. This manual provides technical information for OEM engineers and systems integrators regarding the installation and use of DiamondMax hard drives. Drive repair should be performed only at an authorized repair center. For repair information, contact the Maxtor Customer Service Center at 800-2MAXTOR or 408-432-1700.

Before unpacking the hard drive, please review Sections 1 through 4.

CAUTION

Maxtor DiamondMax 4320 hard drives are precision products. Failure to follow these precautions and guidelines outlined here may lead to product failure, damage and invalidation of all warranties.

1 *BEFORE* unpacking or handling a drive, take all proper electro-static discharge (ESD) precautions, including personnel and equipment grounding. Stand-alone drives are sensitive to ESD damage.

2 *BEFORE* removing drives from their packing material, allow them to reach room temperature.

3 During handling, *NEVER* drop, jar, or bump a drive.

4 Once a drive is removed from the Maxtor shipping container, *IMMEDIATELY* secure the drive through its mounting holes within a chassis. Otherwise, store the drive on a padded, grounded, antistatic surface.

5 *NEVER* switch DC power onto the drive by plugging an electrically live DC source cable into the drive's connector. *NEVER* connect a live bus to the drive's interface connector.

Please do not remove or cover up Maxtor factory-installed drive labels. They contain information required should the drive ever need repair.

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Introduction

Maxtor Corporation

Maxtor Corporation has been providing high-quality computer storage products since 1982. Along the way, we've seen many changes in data storage needs. Not long ago, only a handful of specific users needed more than a couple hundred megabytes of storage. Today, downloading from the Internet and CD-ROMs, multimedia, networking and advanced office applications are driving storage needs even higher. Even home PC applications need capacities measured in gigabytes, not megabytes.

Products

Maxtor's products meet those demanding storage capacity requirements with room to spare. They feature proven compatibility and reliability. While **DiamondMax™ 4320** is the latest addition to our family of high performance desktop hard drives, the DiamondMax™ 3400 series hard drives deliver industry-leading capacity, performance and value for many PC applications.

Support

No matter which capacity, all Maxtor hard drives are supported by our commitment to total customer satisfaction and our *No Quibble*® Service guarantee. One call – or a visit to our home page on the Internet (http://www.maxtor.com) – puts you in touch with either technical support or customer service. We'll provide you the information you need quickly, accurately and in the form you prefer – a fax, a downloaded file or a conversation with a representative.

Manual Organization

This hard disk drive reference manual is organized in the following method:

- ❑ Section 1 – Introduction
- ❑ Section 2 – Description
- ❑ Section 3 – Specifications
- ❑ Section 4 – Installation
- ❑ Section 5 – AT Interface
- ❑ Section 6 – Host Software Interface
- ❑ Section 7 – Interface Commands
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- ❑ Appendix – Glossary

Abbreviations

ABBRV	DESCRIPTION	ABBRV	DESCRIPTION
ATA	AT attachment	MB	megabyte
bpi	bits per inch	Mbits/sec	megabits per second
CHS	cylinder - head - sector	MB/sec	megabytes per second
db	decibels	MHz	megahertz
dBA	decibels, A weighted	ms	millisecond
DMA	direct memory access	MSB	most significant bit
ECC	error correction code	mV	millivolts
fci	flux changes per inch	ns	nanoseconds
G	acceleration	PIO	programmed input/output
GB	gigabyte	RPM	revolutions per minute
Hz	hertz	tpi	tracks per inch
KB	kilobyte	UDMA	ultra direct memory access
LBA	logical block address(ing)	µsec	microsecond
LSB	least significant bit	V	volts
mA	milliamperes	W	watts

Conventions

If there is a conflict between text and tables, the table shall be accepted as being correct.

Key Words

The names of abbreviations, commands, fields and acronyms used as signal names are in all uppercase type (e.g., IDENTIFY DRIVE). Fields containing only one bit are usually referred to as the "name" bit instead of the "name" field.

Names of drive registers begin with a capital letter (e.g., Cylinder High register).

Numbering

Numbers that are **not** followed by a lowercase "b" or "h" are decimal values. Numbers that are followed by a lowercase "b" (e.g., 01b) are binary values. Numbers that are followed by a lowercase "h" (e.g., 3Ah) are hexadecimal values.

Signal Conventions

Signal names are shown in all uppercase type.

All signals are either high active or low active signals. A dash character (-) at the end of a signal name indicates that the signal is low active. A low active signal is true when it is below ViL and is false when it is above ViH. A signal without a dash at the end indicates that the signal is high active. A high active signal is true when it is above ViH and is false when it is below ViL.

When a signal is asserted, it means the signal is driven by an active circuit to its true state.

When a signal is negated, it means the signal is driven by an active circuit to its false state.

When a signal is released, it means the signal is not actively driven to any state. Some signals have bias circuitry that pull the signal to either a true or false state when no signal driver is actively asserting or negating the signal. These instances are noted under the description of the signal.

Product Description

Maxtor DiamondMax™ 4320 AT disk drives are 1-inch high, 3.5-inch diameter random access storage devices which incorporate an on-board ATA-4/Ultra DMA controller. High capacity is achieved by a balanced combination of high areal recording density and the latest data encoding and servo techniques.

Maxtor's latest advancements in electronic packaging and integration methods have lowered the drive's power consumption and increased its reliability. Advanced magneto-resistive read/write heads, an state-of-the-art head/disk assembly using an integrated motor/spindle design allow up to four disks in a 3.5-inch package.

Exceptionally high data transfer rates and 9.0 ms access times make these performance series disk drives especially well-suited to high speed desktop and server applications.

DiamondMax 4320 Key Features

ANSI ATA-4 compliant PIO Mode 4 interface (Enhanced IDE)

Supports Ultra DMA Mode 2 for up to 33 MB/sec data transfers

256/512 KB buffer with multi-adaptive cache manager

9.0 ms seek time

Zone density and I.D.-less recording

High reliability with > 500,000 hour MTBF

Outstanding shock resistance at 200 Gs

High durability with 50K constant start/stop cycles

Advanced multi-burst on-the-fly Error Correction Code (ECC)

Extended data integrity with ECC protected data and fault tolerant servo synchronization fields

Supports EPA Energy Star Standards (Green PC Friendly) with ATA powering savings commands

Auto park and lock actuator mechanism

Low power consumption

S.M.A.R.T. Capability

Note: Maxtor defines one megabyte as 10^6 or one million bytes and one gigabyte as 10^9 or one billion bytes.

Product Features

Functional / Interface

Maxtor DiamondMax™ 4320 hard drives contain all necessary mechanical and electronic parts to interpret control signals and commands from an AT-compatible host computer. See Section 3 Product Specifications, for complete drive specifications.

Zone Density Recording

The disk capacity is increased with bit density management – common with Zone Density Recording. Each disk surface is divided into 16 circumferential zones. All tracks within a given zone contain a constant number of data sectors. The number of data sectors per track varies in different zones; the outermost zone contains the largest number of data sectors and the innermost contains the fewest.

Read/Write Multiple Mode

This mode is implemented per ANSI ATA/ATAPI-4 specification. Read/Write Multiple allows the host to transfer a set number of sectors without an interrupt request between them, reducing transfer process overhead and improving host performance.

UltraDMA - Mode 2

Maxtor DiamondMax 4320 hard drives fully comply with the new ANSI Ultra DMA protocol, which greatly improves overall AT interface performance by significantly improving burst and sustained data throughput.

Multi-word DMA (EISA Type B) - Mode 2

Supports multi-word Direct Memory Access (DMA) EISA Type B mode transfers.

Sector Address Translation

All DiamondMax 4320 drives feature a universal translate mode. In an AT/EISA-class system, the drive may be configured to any specified combination of cylinders, heads and sectors (within the range of the drive's formatted capacity). DiamondMax 4320 drives power-up in a translate mode:

MODEL	CYL	HD	SPT	LZone	WPcom	MAX LBA	CAPACITY
91728D8	33,483	16	63	(*)	(*)	33,750,864	17,280 MB
91512D7	29,298	16	63	(*)	(*)	29,532,384	15,120 MB
91303D6	25,249	16	63	(*)	(*)	25,450,992	13,030 MB
91080D5	20,928	16	63	(*)	(*)	21,095,424	10,800 MB
90845D4	16,383	16	63	(*)	(*)	16,514,064	8,455 MB
90648D3	12,556	16	63	(*)	(*)	12,656,448	6,480 MB
90432D2	8,374	16	63	(*)	(*)	8,440,992	4,320 MB

(*) The fields LZone (Landing Zone) and WPcom (Write Pre-comp) are not used by the Maxtor hard drive and the values may be either 0 or the values set by the BIOS. All capacities listed in the above table are based on 10^6 or one million bytes.

Logical Block Addressing

The Logical Block Address (LBA) mode can only be utilized in systems that support this form of translation. The cylinder, head and sector geometry of the drive, as presented to the host, differs from the actual physical geometry. The host AT computer may access a drive of set parameters: number of cylinders, heads and sectors per track, plus cylinder, head and sector addresses. However, the drive can't use these host parameters directly because of zoned recording techniques. The drive translates the host parameters to a set of logical internal addresses for data access.

The host drive geometry parameters are mapped into an LBA based on this formula:

LBA	= (HSCA - 1) + HHDA x HSPT + HNHD x HSPT x HCYA	(1)
	= (HSCA - 1) + HSPT x (HHDA + HNHD x HCYA)	(2)
where	HSCA = Host Sector Address, HHDA = Host Head Address	
	HCYA = Host Cylinder Address, HNHD = Host Number of Heads	
	HSPT = Host Sectors per Track	

The LBA is checked for violating the drive capacity. If it does not, the LBA is converted to physical drive cylinder, head and sector values. The physical address is then used to access or store the data on the disk and for other drive related operations.

Defect Management Zone (DMZ)

Each drive model has a fixed number of spare sectors per drive, all of which are located at the end of the drive. Upon detection of a bad sector that has been reassigned, the next sequential sector is used.

For example, if sector 3 is flagged, data that would have been stored there is "pushed down" and recorded in sector 4. Sector 4 then effectively becomes sector 3, as sequential sectors are "pushed down" across the entire drive. The first spare sector makes up for the loss of sector 3, and so maintains the sequential order of data. This push down method assures maximum performance.

On-the-Fly Hardware Error Correction Code (ECC)

33 bits, single burst, guaranteed

Software ECC Correction

81 bits, single burst, guaranteed
33 bits, double bursts, guaranteed

Automatic Park and Lock Operation

Immediately following power down, dynamic braking of the spinning disks delays momentarily allowing the read/write heads to move to an inner mechanical stop. A small fixed magnet holds the rotary actuator in place as the disk spins down. The rotary actuator is released only when power is again applied.

Cache Management

Buffer Segmentation

The data buffer is organized into two segments: the data buffer and the micro controller scratch pad. The data buffer is dynamically allocated for read and write data depending on the commands received. A variable number of read and write buffers may exist at the same time.

Read-Ahead Mode

Normally, this mode is active. Following a read request, disk read-ahead begins on the first sector and continues sequentially until the allocated buffer is full. If a read request is received during the read-ahead operation, the buffer is examined to determine if the request is in the cache. If a cache hit occurs, read-ahead mode continues without interruption and the host transfer begins immediately.

Automatic Write Reallocation (AWR)

This feature is part of the write cache and reduces the risk of data loss during deferred write operations. If a disk error occurs during the disk write process, the disk task stops and the suspect sector is reallocated to a pool of alternate sectors located at the end of the drive. Following reallocation, the disk write task continues until it is complete.

Write Cache Stacking

Normally, this mode is active. Write cache mode accepts the host write data into the buffer until the buffer is full or the host transfer is complete. A command complete interrupt is generated at the end of the transfer.

A disk write task begins to store the host data to disk. Host write commands continue to be accepted and data transferred to the buffer until either the write command stack is full or the data buffer is full. The drive may reorder write commands to optimize drive throughput.

Major HDA Components

Drive Mechanism

A brush-less DC direct drive motor rotates the spindle at 5,400 RPM (±0.1%). The dynamically balanced motor/spindle assembly ensures minimal mechanical run-out to the disks. A dynamic brake provides a fast stop to the spindle motor upon power removal. The speed tolerance includes motor performance and motor circuit tolerances.

Rotary Actuator

All DiamondMax™ 4320 drives employ a rotary voice coil actuator which consists of a moving coil, an actuator arm assembly and stationary magnets. The actuator moves on a low-mass, low-friction center shaft. The low friction contributes to fast access times and low power consumption.

Read/Write Electronics

An integrated circuit mounted within the sealed head disk assembly (near the read/write heads) provides up to eight head selection (depending on the model), read pre-amplification and write drive circuitry.

Read/Write Heads and Media

Low mass, low force magneto-resistive read/write heads record data on 3.5-inch diameter disks. Maxtor uses a sputtered thin film medium on all disks for DiamondMax 4320 drives.

Air Filtration System

All DiamondMax 4320 drives are assembled in a Class 100 controlled environment. Over the life of the drive, a 0.1 micron filter and breather filter located within the sealed head disk assembly (HDA) maintain a clean environment to the heads and disks. DiamondMax 4320 drives are designed to operate in a typical office environment with minimum environmental control.

Microprocessor

The microprocessor controls the following functions for the drive electronics:

Command execution

Cache management

Data correction and error recovery

Diagnostic execution

Data sequencing

Head positioning (including error recovery)

Host interface

Index detection

Spin speed control

Seeks

Servo

S.M.A.R.T.

Subsystem Configuration

Dual Drive Support

Two drives may be accessed via a common interface cable, using the same range of I/O addresses. The drives are jumpered as device 0 or 1 (Master/Slave), and are selected by the drive select bit in the Device/Head register of the task file.

All Task File registers are written in parallel to both drives. The interface processor on each drive decides whether a command written to it should be executed; this depends on the type of command and which drive is selected. Only the drive selected executes the command and activates the data bus in response to host I/O reads; the drive not selected remains inactive.

A master/slave relationship exists between the two drives: device 0 is the master and device 1 the slave. When J50 is closed (factory default, figure 2-1), the drive assumes the role of master; when open, the drive acts as a slave. In single drive configurations, J50 must be closed.

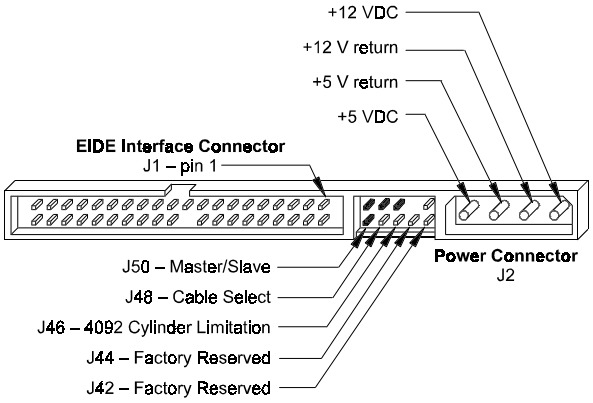
Cable Select Option

CSEL (cable select) is an optional feature per ANSI ATA specification. Drives configured in a multiple drive system are identified by CSEL's value:

– If CSEL is grounded, then the drive address is 0.
– If CSEL is open, then the drive address is 1.

Jumper Location/Configuration

Darkened jumper pins indicate factory-installed (default) shunts.



JUMPER CONFIGURATION	J50	J48	J46	J44	J42
Master/Slave					
Only drive in single drive system*	C				
Master drive in dual drive system*	C				
Slave drive in dual drive system	O				
Cable Select					
Disabled*		O			
Enabled		C			
4092 Cylinder Limitation					
Disabled*			O		
Enabled			C		
Factory Reserved				O	
Factory Reserved					O

Key * = Default C = Closed *(jumper installed)* O = Open *(no jumper installed)*

Figure 2-1
PCBA Jumper Location and Configuration

4092 Cylinder Limitation

On some older BIOS', primarily those that auto-configure the disk drive, a hang may occur when the drive cylinder value exceeds 4096. The 4092 Cylinder Limitation jumper reduces the capacity in the Identify Drive to 4092 allowing large capacity drives to work with older BIOS'. A software driver is required to access the full capacity of the drive.

Product Specifications

Models and Capacities

MODEL	91728D8	91512D7	91303D6	91080D5	90845D4	90648D3	90432D2
Formatted Capacity *(MB LBA Mode)*	17,280	15,120	13,030	10,800	8,455	6,480	4,320
Maxtor defines one megabyte as 10^6 or one million bytes and one gigabyte as 10^9 or one billion bytes.							

Drive Configuration

MODEL	91728D8	91512D7	91303D6	91080D5	90845D4	90648D3	90432D2
Integrated Controller / Interface	ATA-4 / Ultra DMA						
Encoding Method	EPR4 RLL 16/17						
Interleave	1:1						
Servo System	Embedded						
Buffer Size / Type	1- and 2-Disk Models: 256 KB SDRAM / 3- and 4-Disk Models: 512 KB SDRAM						
Data Zones per Surface	16						
Data Surfaces / Heads	8	7	6	5	4	3	2
Number of Disks	4	4	3	3	2	2	1
Areal Density	3,100 Mb / in^2						
Tracks per Surface *(Cylinders)*	13,295						
Track Density	13,000 tpi						
Recording Density	186 - 237 kbpi						
Bytes per Sector / Block	512						
Sectors per Track	230 - 384						
Sectors per Drive	33,750,864	29,532,384	25,450,992	21,095,424	16,514,064	12,656,448	8,440,992

Performance Specifications

MODEL	91728D8	91512D7	91303D6	91080D5	90845D4	90648D3	90432D2
Seek Times *(typical)*							
Track-to-Track	0.9 ms						
Average	9.0 ms						
Maximum	< 20 ms						
Average Latency	5.55 ms						
Rotational Speed *(±0.1%)*	5,400 RPM						
Controller Overhead	< 0.5 ms						
Data Transfer Rate							
To/from Interface *(Ultra DMA - Mode 2)*	up to 33.0 MB/sec						
To/from Interface *(PIO 4/Multi-word DMA - Mode 2)*	up to 16.7 MB/sec						
To/from Media	up to 22.0 MB/sec						
Start Time *(0 to Drive Ready)*	< 8.8 sec typical						

Physical Dimensions

PARAMETER	STANDARD	METRIC
Height	1.02 inch	25.9 millimeters
Length	5.77 inches	146.6 millimeters
Width	4.02 inches	102.1 millimeters
Weight	1.3 pounds	0.59 kilograms

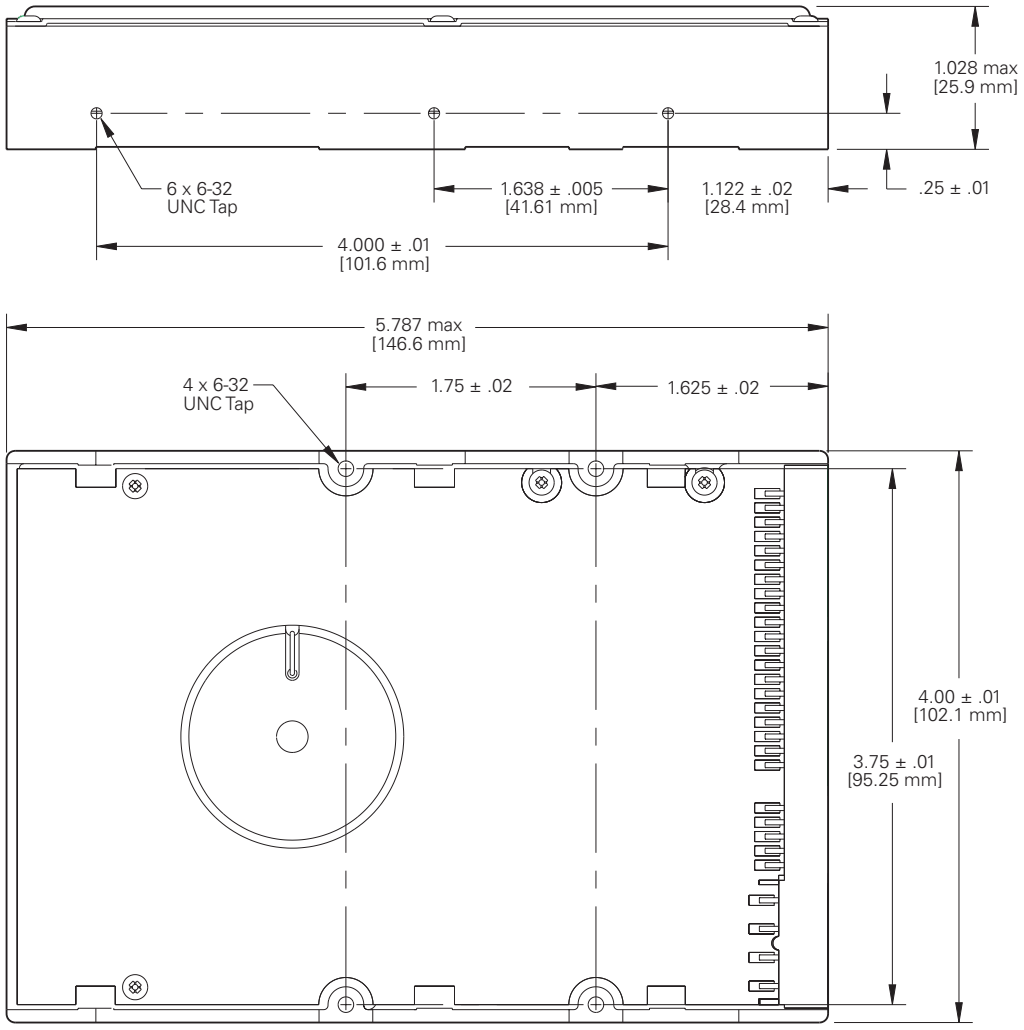


Figure 3 - 1
Outline and Mounting Dimensions

Power Requirements (Average)

MODE	12V ± 5%	5V ± 5%	POWER
Spin-up *(peak)*	1670 mA	330 mA	21.7 W
Seek	670 mA	350 mA	9.8 W
Read/Write	230 mA	420 mA	4.9 W
Idle	240 mA	250 mA	4.1 W
Standby	16 mA	150 mA	0.9 W
Sleep	14 mA	50 mA	0.4 W

Power Mode Definitions

Spin-up

The drive is spinning up following initial application of power and has not yet reached full speed.

Seek

A random access operation by the disk drive.

Read/Write

Data is being read from or written to the drive.

Idle

The drive is spinning, the actuator is parked and powered off and all other circuitry is powered on. The drive is capable of responding to read commands within 40 ms.

Standby

The spin motor is not spinning. The drive will leave this mode upon receipt of a command that requires disk access. The time-out value for this mode is programmable. The buffer is active to accept write data.

Sleep

This is the lowest power state – with the interface set to inactive. A software or hardware reset is required to return the drive to the Standby state.

EPA Energy Star Compliance

Maxtor Corporation supports the goals of the U.S. Environmental Protection Agency's Energy Star program to reduce the electrical power consumption of computer equipment.

Environmental Limits

PARAMETER	OPERATING	NON-OPERATING/STORAGE
Temperature	5° C to 55° C	low temperature (-40° C) high temperature (71° C) per MIL-STD-810E, method 501.3, climatic category; hot-induced conditions.
Thermal Gradient	25° C per hour (*maximum)*	
Relative Humidity	5% to 95% *(non-condensing)*	
Wet Bulb	27° C *(maximum)*	
Altitude	-200 to 10,000 feet	-200 to 40,000 feet
Acoustic Noise *(Idle mode)*	35 dBA average sound power *(per ISO 7779, 10 microphone)*	

Shock and Vibration

PARAMETER	OPERATING	NON-OPERATING
Mechanical Shock	20 Gs, 2.0 ms, no errors	200 Gs, 2.0 ms, no damage
Rotational Shock		15,000 Rad/sec/sec, no damage
Random Vibration	10 - 45 Hz at 0.004 G^2/Hz 48 - 62 Hz at 0.008 G^2/Hz 65 - 300 Hz at 0.004 G^2/Hz 301 - 500 Hz at 0.0006 G^2/Hz no errors	10 - 2,000 Hz at 2.15 Grms, no damage
Swept Sine Vibration 5 - 20 Hz 21 - 300 Hz	 0.049 inches double amplitude 1.0 G peak amplitude (0 - peak)	

Reliability Specifications

AFR

< 1.7%

The annualized average failure rate (AFR) applies to the period prior to the expiration of component design life, and is based on failures chargeable to Maxtor.

MTBF

> 500,000 hours

Maxtor does not differentiate between various usage profiles (e.g., power-on hours, power saving modes, non-operating periods or operating temperatures within the published specification.)

Quality Acceptance Rate

TBD *(< 1,500 DPPM)*

The quality acceptance rate indicates the percentage of Maxtor products successfully installed by our customers, and/or the number of defective parts per million (DPPM) encountered during the entire installation process.

Start/Stop Cycles

50,000 *(minimum)*

This indicates the minimum cycles for reliable start/stop function at a ≥ 60% confidence level.

Data Reliability

< 1 per 10^{14} bits read

Data errors (non-recoverable). Average data error rate allowed with all error recovery features activated.

Component Design Life

5 years *(minimum)*

Component design life is defined as a.) the time period before identified wear-out mechanisms impact the failure rate, or b.) the time period up to the wear-out point when useful component life expires.

EMC/EMI

Radiated Electromagnetic Field Emissions - EMC Compliance

The hard disk drive mechanism is designed as a subassembly for installation into a suitable enclosure and is therefore not subject to Subpart J of Part 15 of FCC Rules (47CFR15) or the Canadian Department of Communications Radio Interference Regulations. Although not required, the disk mechanism has been tested within a suitable end-use product and found to comply with Class B limits of the FCC Rules and Regulations of the Canadian Department of Communications.

The CE Marking indicates conformity with the European Union Low Voltage Directive (73/23/EEC) when the disk mechanism is installed in a typical personal computer. Maxtor recommends that testing and analysis for EMC compliance be performed with the disk mechanism installed within the user's end-use application.

Canadian Emissions Statement

This digital apparatus does not exceed the Class B limits for radio noise emissions from digital apparatus as set out in the radio interference regulations of the Canadian department of communications.

Le present appareil numerique n'emet pas de bruit radioelectriques depassant les limites applicables aux appareils numeriques de Class B prescrites dans le reglement sur le brouillage radioelectrique edicte par le ministere des communications du Canada.

Safety Regulatory Compliance

All Maxtor hard drives comply with relevant product safety standards such as CE, CUL, TUV and UL rules and regulations. As delivered, Maxtor hard drives are designed for system integration before they are used.

Handling and Installation

Pre-formatted Drive

This Maxtor hard drive has been formatted at the factory. Do not use a low-level formatting program.

Important Notice

There are a number of system BIOS's currently in use which do not support hard drives with more than 4095 cylinders (2.1 gigabytes). This section contains information describing the conditions which may identify this limitation. In order to obtain the full capacity of your Maxtor drive, you will need to follow the recommended installation instructions.

Hard Drive Handling Precautions

- During handling, *NEVER* drop, jar, or bump a drive. Handle the drive by its sides and avoid touching the printed circuit board assembly (PCBA).
- Hard drives are sensitive to electrostatic discharge (ESD) damage. Use proper ESD practices by grounding yourself and the computer system the hard drive will be installed in.
- Allow the hard drive to reach room temperature *BEFORE* installing it in your computer system.
- *NEVER* switch DC power onto the drive by plugging an electrically live DC source cable into the drive's connector. *NEVER* connect a live connector to the hard drive's IDE interface connector.

Electro-Static Discharge (ESD)

To avoid some of the problems associated with ESD, Maxtor advises that anyone handling a disk drive use a wrist strap with an attached wire connected to an earth ground. Failure to observe these precautions voids the product warranty.

Manufacturers frequently experience "unsolved" component/hardware malfunctions often caused by ESD. To reduce the incidence of ESD-related problems, Maxtor recommends that any electronics manufacturing plans include a comprehensive ESD program, the basic elements and functions of which are outlined here:

ESD Program Element	*ESD Program Function*
Management	*Institute and maintain*
Chief coordinator	*Organize and enforce*
Multi-department committee	*Evaluate and improve*
Employee training	*Educate and inform*

ESD program supplies typically include: wrist- and foot-worn grounding straps; counter-top and floor antistatic matting; wrist strap testers; ESD video and training materials. Sources for such supplies include:

Static Control Systems – 3M	Charleswater
225-4S, 3M Center	93 Border St.
St. Paul, MN 55144	West Newton, MA 02165-9990

Maxtor also offers a complete video training package, "Care and Handling of Maxtor Disk Drives." Contact your Maxtor representative for details.

Unpacking and Inspection

Retain any packing material for reuse. Inspect the shipping container for evidence of damage in transit. Notify the carrier immediately in case of damage to the shipping container.

As they are removed, inspect drives for evidence of shipping damage or loose hardware. If a drive is damaged (and no container damage is evident), notify Maxtor immediately for drive disposition.

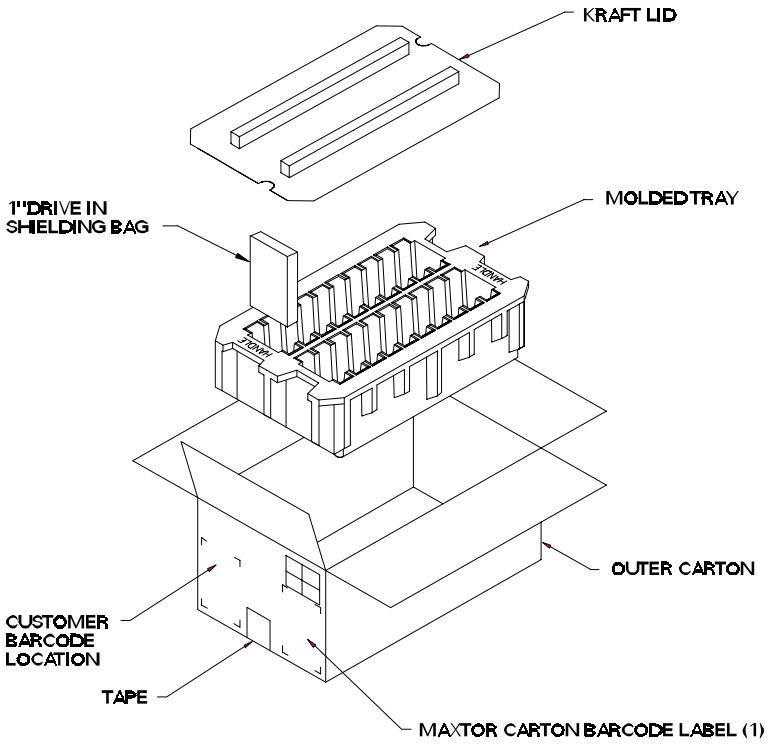


Figure 4 - 1
Multi-pack Shipping Container

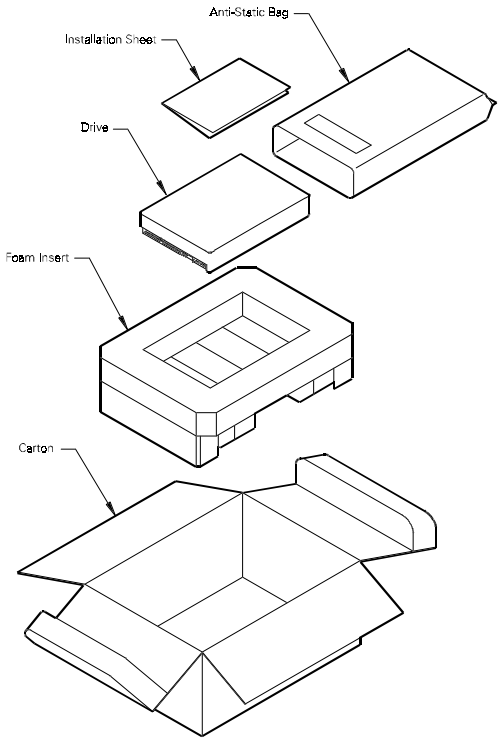


Figure 4 - 2
Single Pack Shipping Container (Option A)

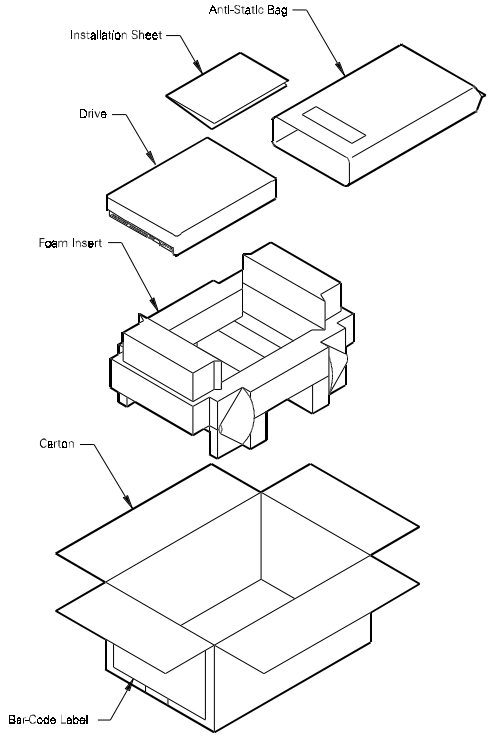


Figure 4 - 3
Single Pack Shipping Container (Option B)

Repacking

If a Maxtor drive requires return, repack it using Maxtor packing materials, including the antistatic bag.

Physical Installation

Recommended Mounting Configuration

The DiamondMax™ 4320 drive design allows greater shock tolerance than that afforded by larger, heavier drives. The drive may be mounted in any attitude using four size 6-32 screws with 1/8-inch maximum penetration and a maximum torque of 5-inch pounds. See Figure 3-1 for mounting dimensions. Allow adequate ventilation to the drive to ensure reliable operation.

1 Before You Begin

IMPORTANT – PLEASE READ!

Please read this Installation Sheet completely before installing the Maxtor hard drive. It gives general information for installing a Maxtor hard drive in a **typical** computer system.

If you don't understand the installation steps, have a qualified computer technician install the hard drive.

Handling Precautions

Allow the hard drive to reach room temperature *BEFORE* installing it in your computer system.

Hard drives are sensitive to electrostatic discharge (ESD) damage.
Handle the drive by its sides. *DO NOT* touch the printed circuit board assembly.

NEVER drop, jar, or bump the drive.

DON'T connect/disconnect any drive cables when the power is on.

DON'T use any low-level formatting software on this drive.

System Requirements

- IDE/AT interface
- 486 processor or higher
- Operating System Requirements
  - For drives less than or equal to 8.4 GB: DOS 5.0 or higher
  - For drives larger than 8.4 GB:
    - √ Installing as Boot drive (Primary Master) requires **full** installation set of Windows 95 or higher (not upgrade).
    - √ Installing as non-Boot drive (Primary Slave, Secondary Master or Slave) requires that Windows 95 or higher be installed on the Boot drive.

Tools for Installation

The following tools are needed to complete the installation of your Maxtor hard drive:

- A small Phillips head screw driver
- Small needle-nose pliers or tweezers
- Your computer user's manual
- Operating system software

Drive Identification Information

Copy the following information from the label on the top cover of the Maxtor hard drive for future reference:

Model Number _____Serial Number _____

Cylinders _____ Heads _____ Sectors _____

Capacity Barriers

Due to operating system limitations, DOS cannot access the full capacity of drives larger than 8.4 GB. The Microsoft Windows 95 operating system or equivalent (full installation), NOT a Windows 95 upgrade from DOS (Windows 3.1 or 3.11), is required to obtain the full capacity of any hard drive larger than 8.4 GB.

Protecting Your Existing Data

Periodic backup of important data is always a good idea. Whenever your computer is on, there is the potential for losing data on your hard drive. This is especially true when running disk utilities or any software that directly manipulates your files. Maxtor recommends that you **make a backup copy** of the files on any existing hard drives. If required, this data may then be copied to the Maxtor hard drive after it has been installed in your computer. Refer to your computer user's manual for detailed data backup instructions.

2 General Requirements

System Hardware Requirements

The minimum system Maxtor recommends for drives 8.4 GB or less is a 486 DX 66 MHz system. For drives larger than 8.4 GB, we recommend a Pentium-class system.

BIOS Requirements

System BIOS dated prior to September 1997 do not support drives greater than 8.4 GB. To obtain the full capacity of a drive larger than 8.4 GB, upgrade the BIOS, install a BIOS enhancer card or use the MaxBlast installation software (version 9.06 or newer).

Ultra Direct Memory Access (UDMA)

UDMA mode on a Maxtor hard drive will only activate when the drive is installed in a system with full UDMA capability, i.e., a mother board or interface card with the UDMA chips and the associated UDMA software drivers.

OS Requirements for Large Capacity Hard Drives

A full installation of the Windows 95 operating system is required for hard drives larger than 8.4 GB when the drive is a Primary Master. An upgrade to Windows 95 from Windows 3.11 and/or the DOS operating system **will not** support drive capacities greater than 8.4 GB when the drive is a Primary Master.

3 Hard Drive Identification

IDE stands for Integrated Drive Electronics and EIDE is Enhanced IDE. The IDE or EIDE interface is designed to support two devices – typically hard drives – on a single ribbon cable through one 40 pin connector on the mother board or interface card.

Some mother boards and interface cards may have a second IDE/EIDE connector to support two additional IDE devices. The IDE/EIDE interface is identified as a primary or secondary interface. In systems with only a single connector on the mother board or interface card, it is the primary IDE/EIDE interface. To add a second IDE/EIDE interface requires a special interface card. In systems with two connectors on the mother board or interface card, one is the primary and the other as the secondary.

The primary interface must be used for at least one IDE device before connecting any devices to the secondary IDE interface.

Ribbon cable lengths are limited to 18 inches and have two or three 40 pin connectors. This cable is referred to as a parallel cable and IDE devices may be connected anywhere on the cable. One of the connectors is attached to the IDE connector on the mother board or interface card and the remaining connector(s) are available for the IDE devices.

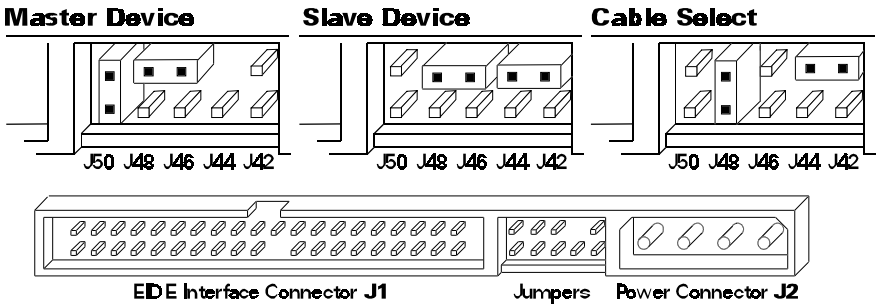
Identifying IDE Devices on the Interface

Each device must be identified as either the Master or Slave device on that interface (cable). Each cable must have a Master before it can have a Slave device on the cable. There cannot be two Master or two Slave devices on the same cable.

IDE devices use jumpers to designate the Master/Slave identification of the device. Each manufacturer may have its own jumpering scheme to identify the device as a Master or Slave and its relationship to other IDE devices attached to the same cable.

Jumper Settings

A jumper is a small piece of plastic that slides over a pair of configuration pins on the drive to activate a specific function. The jumper illustration below shows three valid jumper settings for Maxtor hard drives – Master, Slave and Cable Select. Maxtor hard drives can be set as either a Master or a Slave device. There are no other jumpers to set when the Maxtor drive is installed on the same ribbon cable with another IDE device.



Rear View of Maxtor Hard Drive
Master, Slave and Cable Select Settings

Before installing the drive in the computer, you **must** determine how the jumpers on the Maxtor hard drive are to be set for your system based upon the use of the Maxtor hard drive as either a Master or Slave device. Maxtor hard drives are shipped with the Master jumper setting enabled.

IMPORTANT: If a Maxtor hard drive is being added to a system on the same cable with an existing IDE device, it may be necessary to re-configure the jumpers on the existing device to insure that the system will properly recognize both devices. Information regarding the correct jumper configurations on other IDE devices is available in their product documentation or from the manufacturer of that device.

Systems Using Cable Select

IMPORTANT – Most systems do not use this feature. Unless you are sure that your computer system supports Cable Select, do not set up the drive with this feature enabled.

Maxtor hard drives support Cable Select. The Cable Select method of drive identification allows the system to identify Master and Slave IDE devices based upon the position (connector) the IDE device is attached to on the interface (ribbon) cable.

A special IDE cable select interface (ribbon) cable is **required** for systems using the Cable Select feature.

Systems that use Cable Select do not support the standard Master/Slave definitions described above and the standard IDE interface (ribbon) cable **cannot** be used on these systems. If your system supports this feature, refer to the system user's manual or contact the system manufacturer for specific procedures for installing hard drives.

On Maxtor hard drives, Cable Select is enabled by installing a jumper on J48.

Relationship to Other IDE Devices

Maxtor recommends that its hard drives be configured as a Master device to any IDE device that is not a hard drive (e.g., CD-ROM's, Tape drives, Zip Drives etc.).

4 Mounting Drive in System

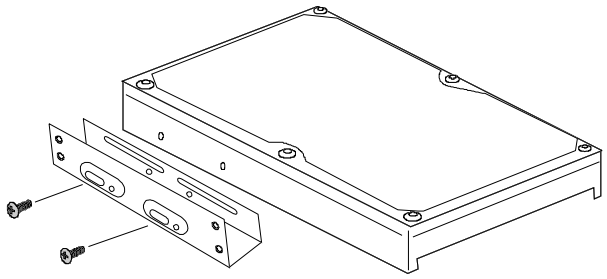
Turn the computer OFF, disconnect the power cord and remove the cover. Refer to the computer user's manual for information on removing the cover.

Each system manufacturer uses different types of cases, including desktop, mini-tower, full tower and other special configurations. As a result, there are many different possible mounting locations that could be used.

In a typical system case, there are specific 3.5 inch and 5.25 inch bays available for storage devices. When a 3.5 inch mounting bay is available, mounting brackets are not required. If a 5.25 inch mounting bay is used, mounting brackets will be required to mount the Maxtor hard drive in the system case. Refer to the system manufacturers user's manual or contact the system manufacturer directly for additional information.

Installing 5.25-inch Mounting Brackets and Rails

If the Maxtor hard drive is being mounted in a 5.25 inch drive bay, the following figure shows how to attach the brackets to the drive. The brackets are not required when mounting in a 3.5 inch drive bay.



Installing in a Device Bay

After the hard drive is prepared with mounting brackets, if required, and the jumpers are set correctly, the drive can be mounted in a device bay and secured. Be sure to secure the drive with all four screws in the device bay. This provides grounding and protection from shock and vibration.

NOTE: Computer systems use different methods for mounting hard drives. Please refer to the computer user's manual or contact the manufacturer for specific mounting instructions.

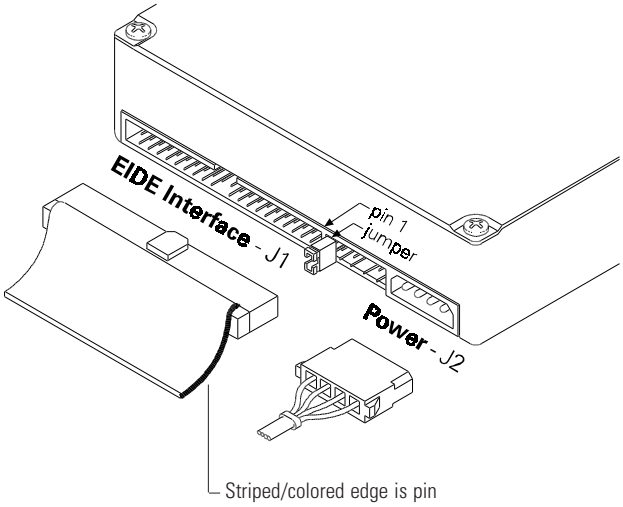
5 Attaching Interface and Power Cables

In order for the computer to recognize that the Maxtor hard drive is in the system, the power cable and IDE interface cable must be properly connected.

1 Attach an available IDE interface connector to **J1** on the Maxtor hard drive.

The striped or colored edge of the IDE interface cable indicates pin 1. Pin 1 on the IDE interface cable connector must match pin 1 on the Maxtor hard drive IDE interface connector – closest to the drive power connector. It must also match pin 1 on the IDE connector on the mother board or IDE interface card. Refer to the system or interface card user's manual for identification of pin 1 on their IDE interface connector.

2 Connect an available power connector to **J2** on the Maxtor hard drive. This connector is keyed and will only fit in one orientation. Do not force the connector.



After attaching the IDE interface cable and the power cable to the Maxtor hard drive, verify that all other cables connected to other devices, the mother board or interface card(s) are correctly seated.

6 Attaching System Cables

The computer system the Maxtor hard drive is being installed in will have its own cable placement and connection methods. This means that the location of the IDE interface connectors on the mother board and/or interface card and the orientation of pin one is determined by the manufacturer. Also, older systems and interface cards may have only a single IDE interface connection – limiting the system to two IDE devices. Refer to the system or interface card user's manual for cable connection and orientation instructions.

Attach the 40-pin IDE interface cable from the Maxtor hard drive to the IDE connector on the mother board or IDE interface card. Insure that the red edge of the ribbon cable is oriented to pin 1 on the interface.

7 System Setup

The following procedures are designed for systems using the DOS 5.0 (or higher), Windows 95 and Windows 98 operating systems. For other operating systems (e.g., Windows NT, OS2, UNIX, LINUX and Novell NetWare), refer to the operating system user's manual for the BIOS setting and other installation requirements.

For drives with capacities larger than 8.4 GB, the full installation set for Windows 95A or 95B (OSR2), Windows 98 or equivalent, is required. Operating systems that do not support extended interrupt 13 cannot access or format a drive larger than 8.4 GB. This is true regardless of BIOS, mother board or interface card support. DOS based operating systems do not support this interrupt and are limited to a maximum drive size that they can format and access of 8.4 GB. It is not possible to upgrade from a DOS operating system to Windows 95 and obtain the full capacity of a drive larger than 8.4 GB.

Setting the BIOS (CMOS)

The SETUP (BIOS) program identifies the system configuration information (e.g., floppy disk drives, hard disk drives, video, etc.) used to identify devices attached to the computer during system boot. This includes the information about what kind and how many IDE hard drives are attached to the system.

IMPORTANT: Please Note – Major BIOS manufacturers like AMI, Award and Phoenix provide their core BIOS programs to system board manufacturers and OEM's who have the capability of making modifications to some of the descriptions and definitions to meet their unique requirements. These changes include, but are not limited to, how to access the BIOS, the appearance of the information on the screens and the location of parameters within the BIOS. Refer to the system or BIOS manufacturers documentation or contact the system manufacturer for the correct procedure to enter the BIOS setup program for your computer. Some manufacturers may use their own unique BIOS definitions and configurations and will also have their own methods for accessing and setting the BIOS. If you have a system that uses such a unique BIOS, refer to the system user's manual or contact the manufacturer for assistance.

WARNING: When entering settings for the Maxtor hard drive, be careful not to change any of the other BIOS settings, or other parts of the system may not work correctly.

BIOS (CMOS) Parameters

In order for the computer system to recognize the new Maxtor hard drive, it is necessary to set the system BIOS with the correct information about the drive. To do this, run the system SETUP (BIOS) program.

The Maxtor hard drive must be identified to the system through the BIOS and it must be registered in the BIOS based upon its position relative to the other IDE devices connected to the system and recorded in the BIOS.

Most newer BIOS' provide the descriptions of Primary Master, Primary Slave, Secondary Master and Secondary Slave (see section 2) which identify the device configuration and location on an IDE interface and its relationship to the other IDE devices on the same interface or ribbon cable.

Some older BIOS versions do not use this terminology for identification and it may be necessary to refer to the system user's manual or BIOS documentation to determine where the drive settings should be set in that specific BIOS. If this information is not available, then it will be necessary to contact the system manufacturer for the correct terminology to correctly identify the drives within the system.

The following are the typical steps to be used to set the hard drive parameters in a BIOS:

A Turn the system ON. During the system start-up sequence, run the SETUP (BIOS) program or similar commands to access the system BIOS.

Note: Newer systems will typically display a message (e.g., press DEL to Enter Setup) identifying how to access the SETUP (BIOS) program.

B Once the SETUP (BIOS) program is active, do one of the following to set the BIOS parameters for the Maxtor hard drive.

1 Enter the BIOS menu where the hard drive settings are displayed, select the correct entry (Primary Master, Primary Slave, Secondary Master or Secondary Slave or their equivalents) to set the parameters for the Maxtor hard drive.

If the SETUP program provides an "AUTO DETECT" capability, use this feature to detect the Maxtor hard drive. If the SETUP program does not have AUTO DETECT, set the drive parameters as defined in step 2. Typically, this feature is available for each individual IDE device. It may be necessary to exit the BIOS, re-boot the system and re-enter the BIOS before the AUTO DETECT operation will take effect.

IMPORTANT After the SETUP program has detected the hard drive, verify that the Logical Block Addressing (LBA) mode is enabled for the drive - as not all BIOS versions set this feature during the AUTO DETECT process.

Comment: When LBA is enabled, some BIOS programs (typically Award) will change the values of the cylinders and heads by dividing the cylinders by 2, 4, 8 or 16 and multiplying the heads by the same value. This operation will not change the capacity of the hard drive.

If the system correctly detects the drive and does not hang during the boot process, proceed to Section 8. If the system hangs during the POST, proceed to Section 9. If Auto Detect did not find the drive and no error message was presented, proceed to step 2 below.

2 Enter the BIOS menu where the hard drive definitions are displayed and select the appropriate entry (Primary Master, Primary Slave, Secondary Master or Secondary Slave – or their equivalents) for the Maxtor hard drive. If the SETUP program does not provide an AUTO DETECT capability, the drive parameters must be set using the User Definable Type (UDT).

Set the Cylinder, Head and Sector values with the values listed on the drive label. The drive label is located on the top cover of the drive. The fields LZone (Landing Zone) and WPcom (Write Pre-comp) are not used by the Maxtor hard drive. These fields may be set to 0 or by the values assigned by the BIOS.

Note: Each BIOS manufacturer uses different methods of identifying the UDT. Newer BIOS' from all manufacturer's will usually include an entry called "User" or "User 1." Older BIOS' vary in the method used to identify the UDT. Following are examples of BIOS UDT: AMI = Type 47, Award = Type 47 and Phoenix = Type 48

Only the cylinder, head and sector values printed on the drive label must be entered. All other values may be zero (0). Set the LBA mode to enabled for this drive. Refer to the system user's manual or contact the system manufacturer for information on enabling LBA.

If the SETUP program does not provide the UDT, set the BIOS to the drive type with the largest capacity of those listed in the BIOS.

C After the drive parameters are entered, follow the SETUP program procedures to save the settings and exit the SETUP program. After changing BIOS settings, saving the values and exiting, the SETUP program should force the system to re-boot.

If you are not sure how the UDT is defined in the BIOS, refer to the computer user's manual or contact the system manufacturer.

8 Hard Drive Preparation

To finish the installation, the drive must be partitioned and formatted. Hard drive partitioning and formatting may be done with the operating system software or with MaxBlast installation software. Select A or B below to complete the preparation of the Maxtor hard drive.

NOTE: Drive letter assignment is controlled by the operating system and not by the BIOS or MaxBlast. The operating system assigns drive letters to all devices as follows: (1) to all hard drives and their partitions; (2) to all other devices like CD-ROM's and tape drives. When adding an additional hard drive to the system, the drive letters will be automatically changed by the operating system.

A Preparing the hard drive using the operating system software.

IMPORTANT Due to operating system limitations, DOS operating systems cannot access the full capacity of drives larger than 8.4 GB. The Windows 95 full installation, not an upgrade from DOS, operating system or equivalent is required to obtain the full capacity of any drive larger than 8.4 GB.

If the system or interface card correctly supports the Maxtor hard drive, the drive may be partitioned and formatted using the operating system software. If the cylinder limitation jumper (J46) is installed or the BIOS does not support the hard drive, the MaxBlast installation software (option B below) **must** be used to prepare the hard drive.

NOTE: All versions of DOS, PC-DOS, DR-DOS and Windows 95A (FAT 16 support) have a partition size limitation of 2.1 GB. For drives larger than 2.1 GB, the drive must be divided into partitions that do not exceed the 2.1 GB limitation. Windows 95B (OSR2) does not have this limitation. Windows NT, OS2, UNIX, LINUX and Novell NetWare may have different limitations but please refer to their documentation or contact the manufacturer to verify their support or limitations.

For detailed operating system installation assistance, refer to the system manufacturers user's manual, the operating system user's manual or contact the manufacturer directly.

B Preparing the hard drive using MaxBlast installation software.

1 Boot the system with the bootable MaxBlast software installation diskette.

2 The MaxBlast installation software will load and the first screen of the program will display. Follow the on-screen prompts to complete the hard drive installation.

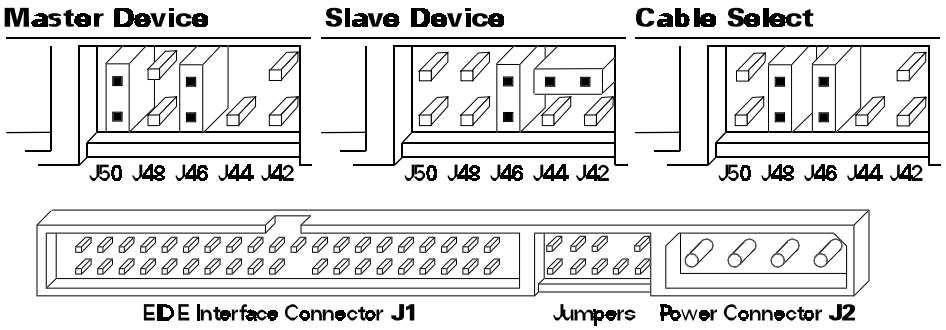
9 System Hangs During Boot

If the system hangs during the boot process after installing the Maxtor hard drive – either before or after setting the system BIOS – the system many have a BIOS with a cylinder limitation. This may occur for hard drives that exceed 2.1 GB. If this happens, do the following:

1 Turn the system OFF.

2 Install the cylinder limitation jumper **(J46)** on the drive. The figure below shows the Maxtor hard drive configured as a Master or Slave device with the cylinder limitation jumper installed.

IMPORTANT: When the Cylinder Limitation jumper (J46) is installed, the Maxtor hard drive must be prepared using MaxBlast installation software.



3 If the BIOS was set to AUTO DETECT, follow the instructions in Section 7 to prepare the hard drive using the MaxBlast installation software.

If other BIOS settings were used, access the system BIOS SETUP program and set the parameters to a **User Definable Type** with 4,092 cylinders, 16 heads and 63 sectors per track for the Maxtor hard drive. Then follow the instructions for setting the BIOS in Section 7 then Section 8 to prepare the hard drive with MaxBlast software.

AT Interface Description

Interface Connector

All DiamondMax™ 4320 AT drives have a 40-pin ATA interface connector mounted on the PCBA. The drive may connect directly to the host; or it can also accommodate a cable connection (max cable length: 18 inches).

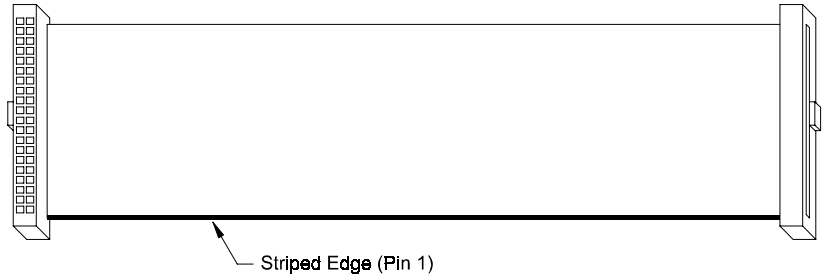


Figure 5-1
Data Connector

Pin Description Summary

PIN	SIGNAL		PIN	SIGNAL
01	Reset -		02	Ground
03	DD7		04	DD8
05	DD6		06	DD9
07	DD5		08	DD10
09	DD4		10	DD11
11	DD3		12	DD12
13	DD2		14	DD13
15	DD1		16	DD14
17	DD0		18	DD15
19	Ground		20	(keypin)
21	DMARQ		22	Ground
23	DIOW -:STOP		24	Ground
25	DIOR -:HDMARDY:HSTROBE		26	Ground
27	IORDY:DDMARDY:DSTROBE		28	CSEL
29	DMACK -		30	Ground
31	INTRQ		32	IOCS16 Obsolete
33	DA1		34	PDIAG -
35	DA0		36	DA2
37	CS0 -		38	CS1 -
39	DASP -		40	Ground

Pin Description Table

PIN NAME	PIN	I/O	SIGNAL NAME	SIGNAL DESCRIPTION
RESET -	01	I	Host Reset	Reset signal from the host system. Active during power up and inactive after.
DD0	17	I/O	Host Data Bus	16 bit bi-directional data bus between host and drive. Lower 8 bits used for register and ECC byte transfers. All 16 bits used for data transfers.
DD1	15	I/O		
DD2	13	I/O		
DD3	11	I/O		
DD4	09	I/O		
DD5	07	I/O		
DD6	05	I/O		
DD7	03	I/O		
DD8	04	I/O		
DD9	06	I/O		
DD10	08	I/O		
DD11	10	I/O		
DD12	12	I/O		
DD13	14	I/O		
DD14	16	I/O		
DD15	18	I/O		
DMARQ	21	O	DMA Request	This signal is used with DMACK for DMA transfers. By asserting this signal, the drive indicates that data is ready to be transfered to and from the host.
DIOW - STOP	23	I	Host I/O Write	Rising edge of Write strobe clocks data from the host data bus to a register on the drive.
DIOR - HDMARDY HSTROBE	25	I	Host I/O Read	Read strobe enables data from a register on the drive onto the host data bus. DMA ready during UltraDMA data in bursts. Data strobe during UltraDMA data out bursts.
IORDY DDMARDY - DSTROBE	27	O	I/O Channel Ready	This signal may be driven low by the drive to insert wait states into host I/O cycles. DMA ready during UltraDMA data out bursts. Data strobe during UltraDMA data in bursts.
CSEL	28		Cable Select	Used for Master/Slave selection via cable. Requires special cabling on host system and installation of Cable Select jumper.
DMACK -	29	I	DMA Acknowledge	This signal is used with DMARQ for DMA transfers. By asserting this signal, the host is acknowledging the receipt of data or is indicating that data is available.
INTRQ	31	O	Host Interrupt Request	Interrupt to the host asserted when the drive requires attention from the host.
IOCS16	32		Device 16 bit I/O	Obsolete
PDIAG -	34	I/O	Passed Diagnostic	Output by drive when in Slave mode; Input to drive when in Master mode.
DA0	35	I	Host Address Bus	3 bit binary address from the host to select a register in the drive.
DA1	33	I		
DA2	36	I		
CS0 -	37	I	Host Chip Select 0	Chip select from the host used to access the Command Block registers in the drive. This signal is a decode of I/O addresses 1F0 - 1F7 hex.
CS1 -	38	I	Host Chip Select 1	Chip select from the host used to access the Control registers in the drive. This signal is a decode of I/O addresses 3F6 - 3F7 hex.
DASP -	39	I/O	Drive Active/Drive 1 Present	Time-multiplexed, open collector output which indicates that a drive is active, or that device 1 is present.
GND	02	N/A	Ground	Signal ground.
	19			
	22			
	24			
	26			
	30			
	40			
KEY	20	N/A	Key	Pin used for keying the interface connector.

PIO Timing

TIMING PARAMETERS		MODE 0	MODE 1	MODE 2	MODE 3	MODE 4
t0	Cycle Time (min)	600 ns	383 ns	240 ns	180 ns	120 ns
t1	Address valid to DIOR-/DIOW- setup (min)	70 ns	50 ns	30 ns	30 ns	25 ns
t2	DIOR-/DIOW- 16-bit (min)	165 ns	125 ns	100 ns	80 ns	70 ns
t2i	DIOR-/DIOW- recovery time (min)				70 ns	25 ns
t3	DIOW- data setup (min)	60 ns	45 ns	30 ns	30 ns	20 ns
t4	DIOW- data hold (min)	30 ns	20 ns	15 ns	10 ns	10 ns
t5	DIOR- data setup (min)	50 ns	35 ns	20 ns	20 ns	20 ns
t6	DIOW- data hold (min)	5 ns	5 ns	5 ns	5 ns	5 ns
t6Z	DIOR- data tristate (max)	30 ns	30 ns	30 ns	30 ns	30 ns
t9	DIOR-/DIOW- to address valid hold (min)	20 ns	15 ns	10 ns	10 ns	10 ns
tRd	Read Data Valid to IORDY active (min)	0	0	0	0	0
tA	IORDY Setup Time	35 ns	35 ns	35 ns	35 ns	35 ns
tB	IORDY Pulse Width (max)	1250 ns	1250 ns	1250 ns	1250 ns	1250 ns

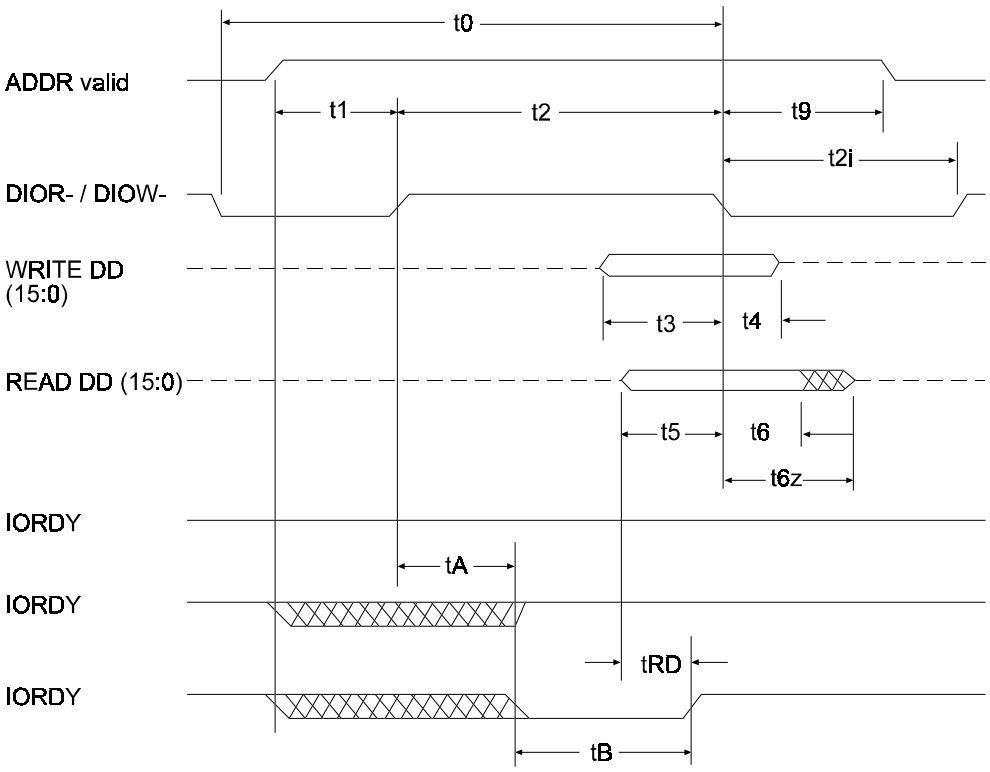


Figure 5 - 2
PIO Data Transfer To/From Device

DMA Timing

TIMING PARAMETERS		MODE 0	MODE 1	MODE 2
t0	Cycle Time (min)	480 ns	150 ns	120 ns
tC	DMACK to DMARQ delay			
tD	DIOR-/DIOW- (min)	215 ns	80 ns	70 ns
tE	DIOR- data access (min)	150 ns	60 ns	
tF	DIOR- data hold (min)	5 ns	5 ns	5 ns
tG	DIOR-/DIOW- data setup (min)	100 ns	30 ns	20 ns
tH	DIOW- data hold (min)	20 ns	15 ns	10 ns
tI	DMACK to DIOR-/DIOW- setup (min)	0	0	0
tJ	DIOR-/DIOW- to DMACK hold (min)	20 ns	5 ns	5 ns
tKr	DIOR- negated pulse width (min)	50 ns	50 ns	25 ns
tKw	DIOW- negated pulse width (min)	215 ns	50 ns	25 ns
tLr	DIOR- to DMARQ delay (max)	120 ns	40 ns	35 ns
tLw	DIOW- to DMARQ delay (max)	40 ns	40 ns	35 ns
tZ	DMACK- to tristate (max)	20 ns	25 ns	25 ns

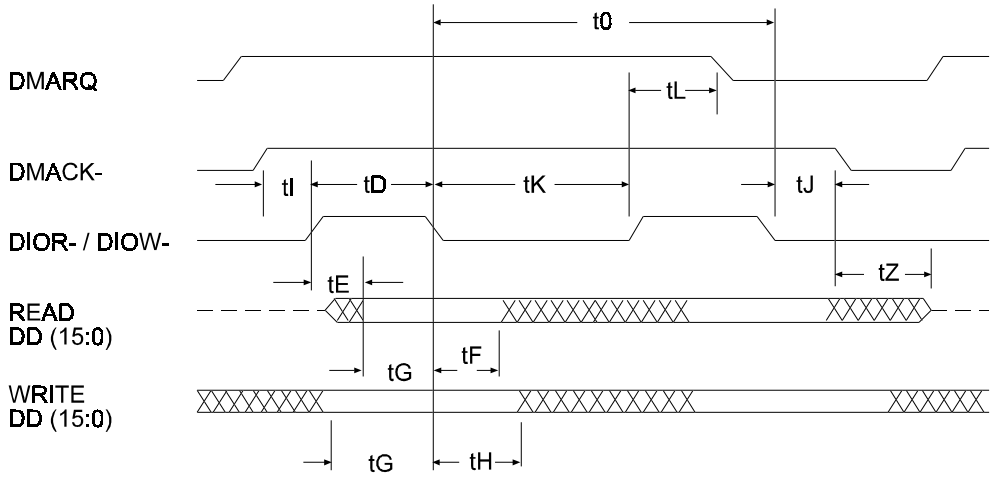


Figure 5 - 3
Multi-word DMA Data Transfer

Ultra DMA Timing

TIMING PARAMETERS (all times in nanoseconds)		**MODE 0**		**MODE 1**		**MODE 2**	
		MIN	MAX	MIN	MAX	MIN	MAX
t_{CYC}	Cycle Time (from STROBE edge to STROBE edge)	114		75		55	
$t2_{CYC}$	Two cycle time (from rising edge to next rising edge or from falling edge to next falling edge of STROBE)	235		156		117	
t_{DS}	Data setup time (at recipient)	15		10		7	70
t_{DH}	Data hold time (at recipient)	5		5		5	
t_{DVS}	Data valid setup time at sender (time from data bus being valid until STROBE edge)	70		48		34	5
t_{DVH}	Data valid hold time at sender (time from STROBE edge until data may go invalid)	6		6		6	20
t_{FS}	First STROBE (time for device to send first STROBE)	0	230	0	200	0	170
t_{LI}	Limited interlock time (time allowed between an action by one agent, either host or device, and the following action by the other agent)	0	150	0	150	0	150
t_{MLI}	Interlock time with minimum	20		20		20	
t_{UI}	Unlimited interlock time	0		0		0	
t_{AZ}	Maximum time allowed for outputs to release		10		10		10
t_{ZAH}	Minimum delay time required for output drivers turning on (from released state)	20		20		20	
t_{ZAD}		0		0		0	
t_{ENV}	Envelope time (all control signal transitions are within the DMACK envelope by this much time)	20	70	20	70	20	70
t_{SR}	STROBE to DMARDY (response time to ensure the synchronous pause case when the recipient is pausing)		50		30		20
t_{RFS}	Ready-to-final-STROBE time (no more STROBE edges may be sent this long after receiving DMARDY- negation)		75		60		50
t_{RP}	Ready-to-pause time (time until a recipient may assume that the sender has paused after negation of DMARDY-)	160		125		100	
t_{IORDYZ}	Pull-up time before allowing IORDY to be released		20		20		20
t_{ZIORDY}	Minimum time device shall wait before driving IORDY	0		0		0	
t_{ACK}	Setup and hold times before assertion and negation of DMACK-	20		20		20	
t_{SS}	Time from STROBE edge to STOP assertion when the sender is stopping	50		50		50	

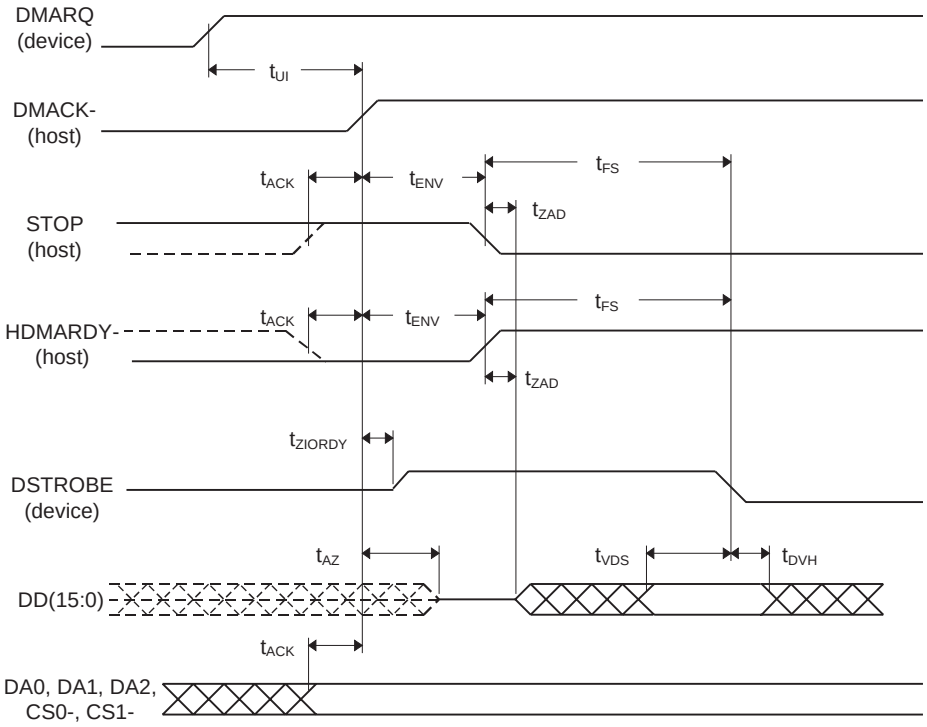


Figure 5 - 4
Initiating an Ultra DMA Data In Burst

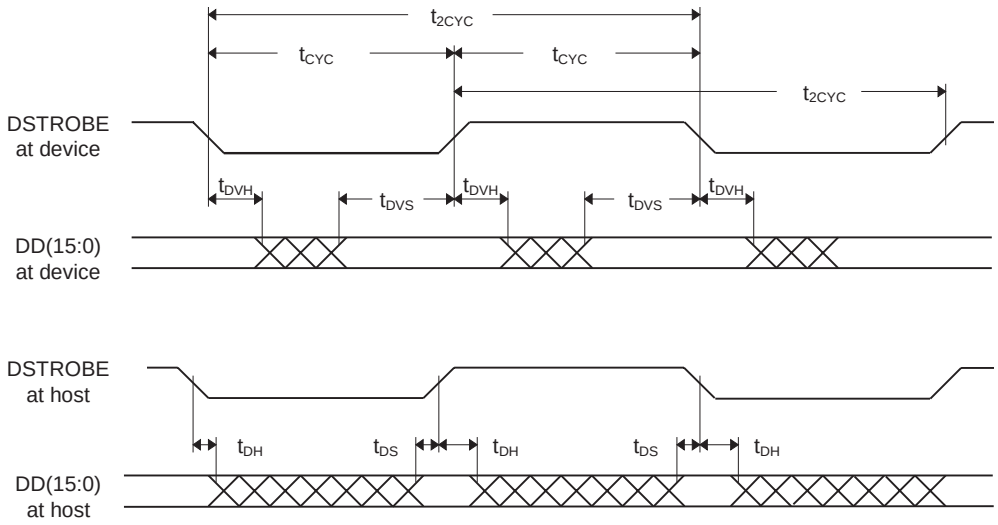


Figure 5 - 5
Sustained Ultra DMA Data In Burst

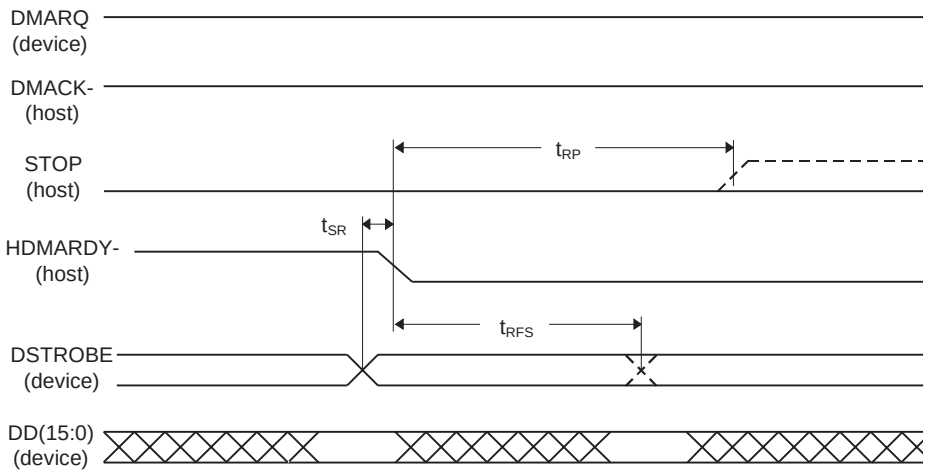


Figure 5 - 6
Host Pausing an Ultra DMA Data In Burst

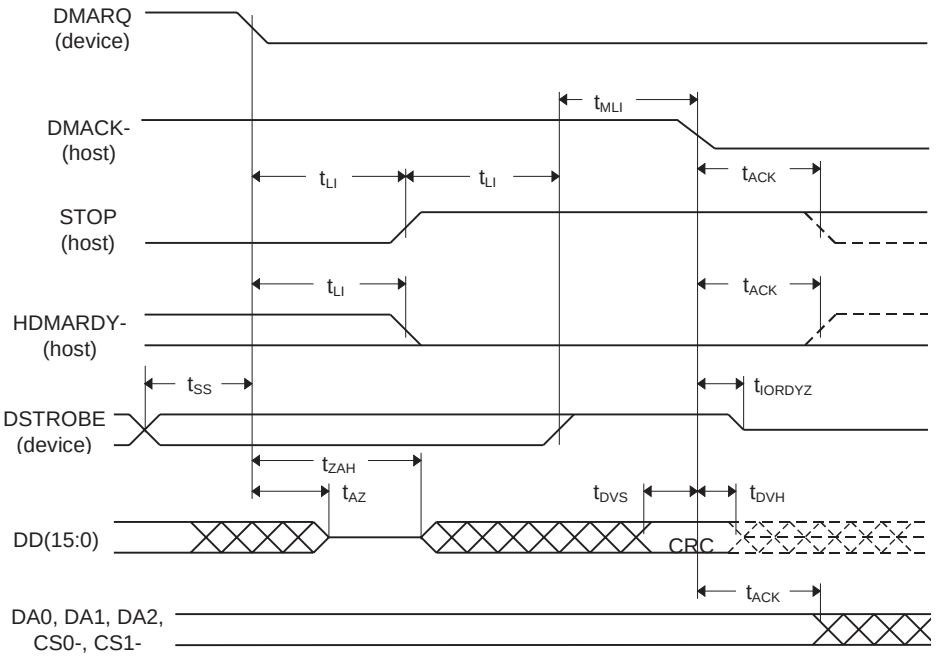


Figure 5 - 7
Device Terminating an Ultra DMA Data In Burst

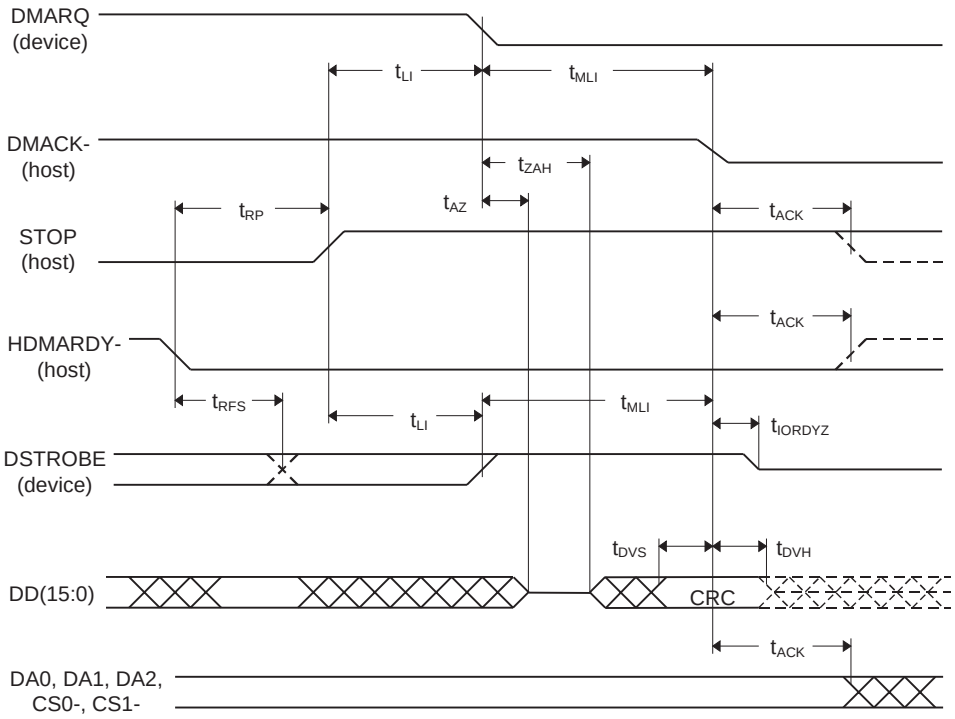


Figure 5 - 8
Host Terminating an Ultra DMA Data In Burst

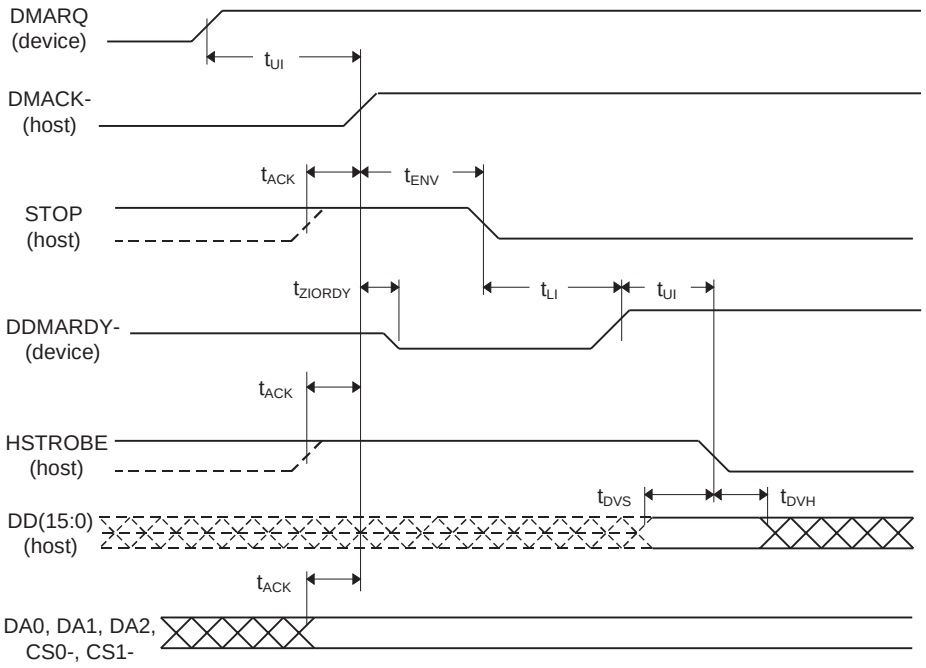


Figure 5 - 9
Initiating an Ultra DMA Data Out Burst

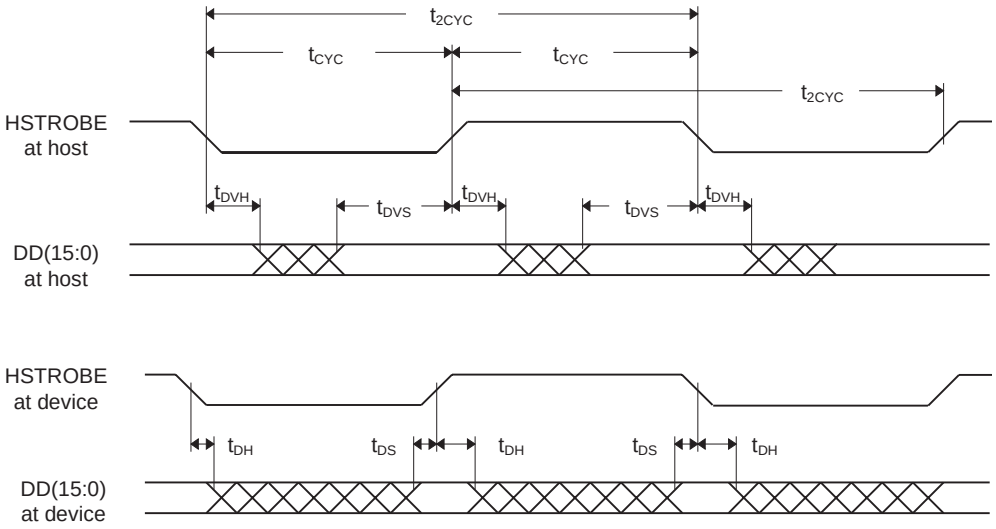


Figure 5 - 10
Sustained Ultra DMA Data Out Burst

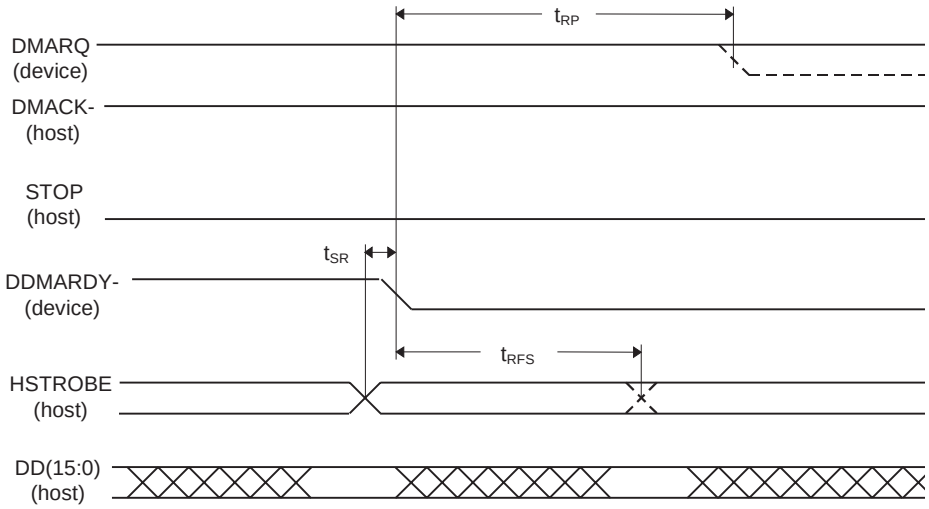


Figure 5 - 11
Device Pausing an Ultra DMA Data Out Burst

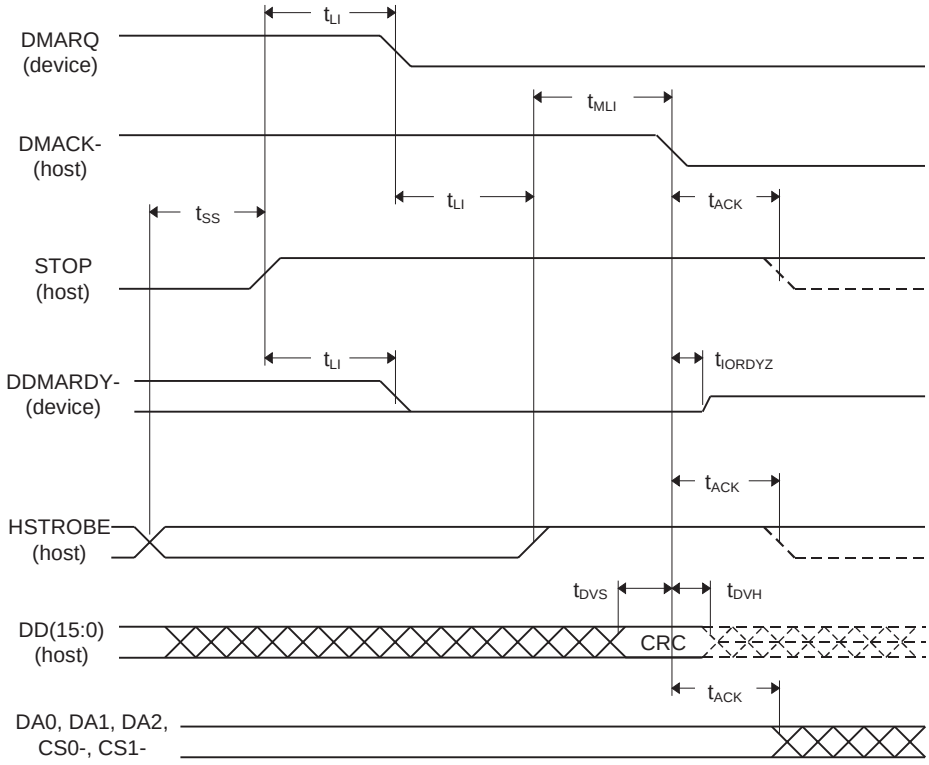


Figure 5 - 12
Host Terminating an Ultra DMA Data Out Burst

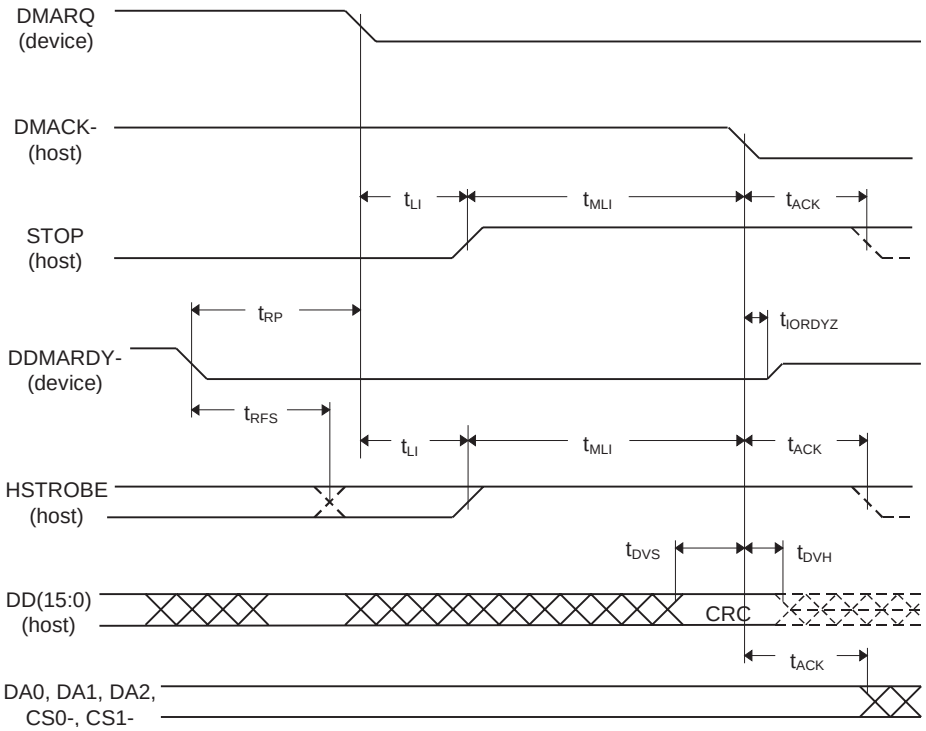


Figure 5 - 13
Device Terminating an Ultra DMA Data Out Burst

Host Software Interface

The host communicates with the drive through a set of controller registers accessed via the host's I/O ports. These registers divide into two groups: the Task File, used for passing commands and command parameters and the Control/Diagnostic registers.

Task File Registers

The Task File consists of eight registers used to control fixed disk operations. The host accesses each register by the I/O port address shown in this Task File register map:

I/O PORT	READ	WRITE
1F0h	Data Register	Data Register
1F1h	Error Register	Features Register
1F2h	Sector Count	Sector Count
1F3h	Sector Number	Sector Number
1F4h	Cylinder Low	Cylinder Low
1F5h	Cylinder High	Cylinder High
1F6h	Drive/Head (SDH)	Drive/Head (SDH)
1F7h	Status Register	Command Register

Data Register

Provides access to the drive's sector buffer for read and write operations. With the exception of ECC byte transfers (which, during Read long and Write long commands, are 8 bits wide), data transfers through the Data register are all 16 bits wide.

Error Register

A read-only register containing specific information regarding the previous command. Data interpretation differs depending on whether the controller is in operational or diagnostic mode. A power up, reset, software reset, or receipt of a diagnostic command sets the controller into diagnostic mode. This mode invalidates contents of the Status register. The contents of the Error register reflect a completion code.

Issuing any command (apart from a Diagnostic command) places the controller into *operational mode*. In operational mode, the Error register is valid only when the Error bit in the Status register is set. The bit definitions for operational mode follow:

7	6	5	4	3	2	1	0
0	ECC	0	IDNF	0	ABRT	TK0	AMNF
Interface CRC	Data ECC Error	Not Used	ID Not Found	Not Used	Aborted Command	Track 0 Error	Address Mark Not Found

Interface CRC – An interface CRC error occurred during an Ultra DMA transfer.

Data ECC Error – An non-correctable ECC error occurred during a Read Sector command.

Firmware Problem – Indicates a firmware problem was detected, (e.g., invalid interrupt, divide overflow).

ID Not Found – Either a matching ID field not found, or a CRC error occurred.

Aborted Command – Invalid commands, write fault, no seek complete, or drive not ready.

Track 0 Error – Track 0 was not found during execution of a Restore command.

Address Mark Not Found – The Address Mark could not be found after an ID match.

Features Register

Enables or disables features through the Set Features command.

Sector Count Register

Holds the number of sectors to be sent during a Read or Write command, and the number of sectors per track during a Format command. A value of zero in this register implies a transfer of 256 sectors. A multi-sector operation decrements the Sector Count register. If an error occurs during such an operation, this register contains the remaining number of sectors to be transferred.

Sector Number Register

Holds the starting sector number for any disk operation. The register is updated as each sector is processed in a multi-sector operation.

Cylinder Number Registers

Two 8-bit Cylinder Number registers (Low and High) specify the starting cylinder for disk operation.

Device/Head Register

Used to specify the drive and head number to be operated on during any disk operations. Within the context of a Set Parameters command, this register specifies the maximum number of heads on the drive. Bit definitions follow:

7	6	5	4	3	2	1	0
1	LBA	1	DRV	HS3	HS2	HS1	HS0
	Mode		Drive Select		Head Select	Head Select	Head Select

Select LBA Mode – Enabling this bit for commands not supported by LBA mode will abort the selected command. When set, the Task File register contents are defined as follows for the Read/Write and translate command:

CONTENTS	LBA BITS
Sector Number	0 - 7
Cylinder Low	8 - 15
Cylinder High	16 - 23
Drive/Head	24 - 27

Drive Select – Set to 0 to select the master drive; set to 1 to select the slave drive.

Head Select – Specifies the binary coded address of the head to be selected.

Status Register

Contains results of the last command executed, and the drive's status. The other seven Task File registers may be read only when bit 7 (BUSY) of the Status register is low. Reading any of the Task File registers when BUSY is high returns the value of the Status register. Reading the Status register also clears any interrupt request to the host. Bit definitions follow:

7	6	5	4	3	2	1	0
BUSY	**DRD**Y	**D**F	**D**SC	**DR**Q	0	0	**ERR**
Controller Busy	**D**evice **R**eady	**D**evice Fault	**D**evice Seek Complete	**D**ata **R**equest			**E**rror

Controller Busy – Goes active when a command is written to the Command register, indicating controller task execution. After a command, this bit resets.

Device Ready – Indicates that the drive is ready for commands. If drive ready is not present, all commands abort.

Device Fault – Indicates the drive's detection of a write fault condition, causing all commands to abort.

Device Seek Complete – Signifies a seek completion, and that the drive is on track.

Data Request – Indicates that the drive's sector buffer is ready for data transfer.

Error – The Error bit sets when the previous command has completed with a non-recoverable error.

Command Register

Contains code for the command to be performed. Additional command information should be written to the task file before the Command register is loaded. When this register is written, the BUSY bit in the Status register sets, and interrupt request to the host clears; invalid commands abort. (Detailed information on interface commands is given in Section 7.) Hex values for valid command formats follow:

Read Commands

Read Sector(s)	20h	Normal reads; retries enabled
	21h	Normal reads; retries disabled
	22h	Read Long; retries enabled
	23h	Read Long; retries disabled
Read Verify Sector(s)	40h	Retries enabled
	41h	Retries disabled
Read Sector Buffer	E4h	
Read Multiple	C4h	
Read DMA	C8h	
	C9h	No retries

Write Commands

Write Sector(s)	30h	Normal writes; retries enabled
	31h	Normal writes; retries disabled
	32h	Write Long; retries enabled
	33h	Write Long; retries disabled
Write Verify Sector(s)	3Ch	
Write Sector Buffer	E8h	
Write Multiple	C5h	
Write DMA	CAh	
	CBh	No retries

Mode Set/Check Commands

Set Features	EFh
Set Multiple Mode	C6h

Power Mode Commands

Standby Immediate	94/E0h	Stops drive spindle; do not change time-out value
Idle Immediate	95/E1h	Starts spindle; do not change time-out value
Standby	96/E2h	Stops spindle; change time-out value
Idle	97/E3h	Starts spindle; change time-out value
Check Power Mode	98/E5h	
Set Sleep Mode	99/E6h	

Initialization Commands

Identify Drive	ECh
Initialize Drive Parameters	91h
Re-calibrate	1xh

Seek, Format, and Diagnostic Commands

Seek	7xh
Format Track	50h
Execute Drive Diagnostic	90h

S.M.A.R.T. Commands

Execute S.M.A.R.T.	B0h

Summary

COMMAND NAME	COMMAND CODE									PARAMETERS USED				
	b7	b6	b5	b4	b3	b2	b1	b0		F	SC	SN	C	SDH
Recalibrate	0	0	0	1	x	x	x	x		N	N	N	N	D
Read Sector(s)	0	0	1	0	0	0	L	x		N	Y	Y	Y	Y
Read DMA	1	1	0	0	1	0	0	x		N	Y	Y	Y	Y
Write Sector(s)	0	0	1	1	0	0	L	x		N	Y	Y	Y	Y
Write DMA	1	1	0	0	1	0	1	x		N	Y	Y	Y	Y
Write Verify Sector(s)	0	0	1	1	1	1	0	0		N	Y	Y	Y	Y
Read Verify Sector(s)	0	1	0	0	0	0	0	x		N	Y	Y	Y	Y
Format Track	0	1	0	1	0	0	0	0		N	N	N	Y	Y
Seek	0	1	1	1	x	x	x	x		N	N	Y	Y	Y
Execute Diagnostic	1	0	0	1	0	0	0	0		N	N	N	N	D
Initialize Parameters	1	0	0	1	0	0	0	1		N	Y	N	N	Y
Read Sector Buffer	1	1	1	0	0	1	0	0		N	N	N	N	D
Write Sector Buffer	1	1	1	0	1	0	0	0		N	N	N	N	D
Identify Drive	1	1	1	0	1	1	0	0		N	N	N	N	D
Set Features	1	1	1	0	1	1	1	1		Y	N	N	N	D
Read Multiple	1	1	0	0	0	1	0	0		N	Y	Y	Y	Y
Write Multiple	1	1	0	0	0	1	0	1		N	Y	Y	Y	Y
Set Multiple Mode	1	1	0	0	0	1	1	0		N	Y	N	N	D

TIMER VALUE	TIME-OUT PERIOD
0	Time-out disabled
1 - 240	(value * 5) seconds
241 - 251	((value - 240) * 30) minutes
252	21 minutes
253	Vendor unique period = 10 hours
254	Reserved
255	21 minutes, 15 seconds

Control Diagnostic Registers

These I/O port addresses reference three Control/Diagnostic registers:

I/O PORT	READ	WRITE
3F6h	Alternate Status	Fixed Disk Control
3F7h	Digital Input	Not used

Alternate Status Register

Contains the same information as the Status register in the Task File. However, this register may be read at any time without clearing a pending interrupt.

Device Control Register

Contains the software Reset and Enable bit to enable interrupt requests to the host. Bit definitions follow:

7	6	5	4	3	2	1	0
0	0	0	0	0	SRST	IEN	0
					Reset	IRQ Enable	

Reset – Setting the software Reset bit holds the drive in the reset state. Clearing the bit re-enables the drive. The software Reset bit must be held active for a minimum of 5 μsec.

IRQ Enable – Setting the Interrupt Request Enable to 0 enables the IRQ 14 signal to the host. When this bit is set to 1, IRQ14 is tri-stated, and interrupts to the host are disabled. Any pending interrupt occurs when the bit is set to 0. The default state of this bit after power up is 0 (interrupt enabled).

Digital Input Register

Contains information about the state of the drive. Bit definitions follow:

7	6	5	4	3	2	1	0
x	-WG	-HS3	-HS2	-HS1	-HS0	-DS1	DS0
Reserved	Gate	Head Select 3	Head Select 2	Head Select 1	Head Select 0	Drive Select 1	Drive Select 0

Bit 7 of the host data bus is not driven when this register is read.

-Write Gate – Reflects the state of the active low write gate signal on the drive.

-Head Select 3 through -Head Select 0 – Represents the ones complement of the currently selected head number.

-Drive Select 1 – Is 0 if drive 1 selected; 1 otherwise.

-Drive Select 0 – Is 0 if drive 0 selected; 1 otherwise.

Reset and Interrupt Handling

Reset Handling

One of three different conditions may cause a reset: power on, hardware reset or software reset. All three cause the interface processor to initialize itself and the Task File registers of the interface. A reset also causes a set of the Busy bit in the Status register. The Busy bit does not clear until the reset clears and the drive completes initialization. Completion of a reset operation does not generate a host interrupt.

Task File registers are initialized as follows:

Error	1
Sector Count	1
Sector Number	1
Cylinder Low	0
Cylinder High	0
Drive/Head	0

Interrupt Handling

The drive requests data transfers to and from the host by asserting its IRQ 14 signal. This signal interrupts the host if enabled by bit 1 (IRQ enable) of the Fixed Disk Control register.

Clear this interrupt by reading the Status register, writing the Command register, or by executing a host hardware or software reset.

Interface Commands

The following section describes the commands (and any parameters necessary to execute them), as well as Status and Error register bits affected.

Read Commands

Read Sector(s)
Read Verify Sector(s)
Read Sector Buffer
Read DMA
  Multi-word DMA
  Ultra DMA
Read Multiple
Set Multiple

Write Commands

Write Sector(s)
Write Verify Sector(s)
Write Sector Buffer
Write DMA
  Multi-word DMA
  Ultra DMA
Write Multiple

Set Feature Commands

Set Features Mode

Power Mode Commands

Standby Immediate
Idle Immediate
Standby
Idle
Check Power Mode
Set Sleep Mode
Default Power-on Condition

Initialization Commands

Identify Drive
Initialize Drive Parameters

Read Commands

Read Sector(s)

Reads from 1 to 256 sectors, as specified in the Command Block, beginning at the specified sector. (A sector count of 0 requests 256 sectors.) Immediately after the Command register is written, the drive sets the BSY bit and begins execution of the command. If the drive is not already on the desired track, an implied seek is performed.

Once at the desired track, the drive searches for the data address mark of the requested sector. The data address mark must be recognized within a specified number of bytes, or the Data Address Mark Not Found error will be reported. Assuming the data address mark is found:

1. The data field is read into the sector buffer.
2. Error bits are set (if an error was encountered).
3. The DRQ bit is set.
4. An interrupt is generated.

The DRQ bit is always set, regardless of the presence or absence of an error condition after the sector. Upon command completion, the Command Block registers contain the numbers of the cylinder, head and sector of the last sector read. Back-to-back sector read commands set DRQ and generate an interrupt when the sector buffer is filled at the completion of each sector. The drive is then ready for the data to be read by the host. DRQ is reset and BSY is set immediately when the host empties the sector buffer.

If an error occurs during Read Sector commands, the read terminates at the sector where the error occurred. The host may then read the Command Block to determine the nature of that error, and the sector where it happened. If the error type is a correctable or an non-correctable data error, the flawed data is loaded into the sector buffer.

A Read Long command sets the Long bit in the command code and returns the data and the ECC bytes in the data field of the specified sector. During a Read Long, the drive does not check the ECC bytes to determine if there has been a data error. The Read Long command is limited to single sector requests.

Read Verify Sector(s)

Identical to the Read Sector(s) command, except that:

1. DRQ is never set,
2. No data is transferred back to the host and
3. The long bit is not valid.

Read DMA

Multi-word DMA

Identical to the Read Sector(s) command, except that

1. The host initializes a slave-DMA channel prior to issuing the command,
2. Data transfers are qualified by DMARQ and are performed by the slave-DMA channel and
3. The drive issues only one interrupt per command to indicate that data transfer has terminated and status is available.

Ultra DMA

With the Ultra DMA Read protocol, the control signal (DSTROBE) that latches data from DD(15:0) is generated by the devices which drives the data onto the bus. Ownership of DD(15:0) and this data strobe signal are given DSTROBE to the drive during an Ultra DMA data in burst.

During an Ultra DMA Read burst, the drive always moves data onto the bus, and, after a sufficient time to allow for propagation delay, cable settling, and setup time, the sender shall generate a DSTROBE edge to latch the data. Both edges of DSTROBE are used for data transfers.

Any unrecoverable error encountered during execution of a Read DMA command terminates data transfer after the transfer of all sectors prior to the sector where the error was detected. The sector in error is not transferred. The drive generates an interrupt to indicate that data transfer has terminated and status is available. The error posting is identical to the Read Sector(s) command.

Read Multiple

Performs similarly to the Read Sector(s) command, except that for each READ MULTIPLE command data transfers are multiple sector blocks and the Long bit is not valid.

Execution is also similar to that of the READ SECTOR(S) command, except that:

1. Several sectors are transferred to the host as a block, without intervening interrupts.
2. DRQ qualification of the transfer is required only at the start of each block, not of each sector.

The block count consists of the number of sectors to be transferred as a block. (The block count is programmed by the Set Multiple Mode command, which must be executed prior to the Read Multiple command.) READ LONG command is limited to single sector requests.

When the Read Multiple command is issued, the Sector Count register contains the number of sectors requested — not the number of blocks or the block count. If the number of sectors is not evenly divisible by the block count, as many full blocks as possible are transferred, followed by a final, partial block transfer. This final, partial block transfer is for N sectors, where N = (sector count) modulo (block count)

The Read Multiple operation will be rejected with an Aborted Command error if attempted:

1. Before the Set Multiple Mode command has been executed, or
2. When Read Multiple commands are disabled.

The controller reports disk errors encountered during Read Multiple commands at the start of the block or partial block transfer. However, DRQ still sets, and the transfer occurs normally, along with the transfer of any corrupt data. Remaining block data from the following the sector in error is not valid.

If the Sector Count register contains 0 when the Set Multiple Mode command is issued, Read Multiple and Write Multiple commands are disabled; no error is returned. Once the appropriate action has been taken, the controller resets BSY and generates an interrupt. At power up, or after a hardware or software reset, Read Multiple and Write Multiple commands are disabled by default.

Set Multiple Mode

Enables the controller to perform Read and Write Multiple operations, and establishes the block count for these commands. Before issuing this command, the Sector Count register should be loaded with the number of sectors per block. The drives support block sizes of 2, 4, 8 and 16 sectors.

When this command is received, the controller sets BSY and examines the Sector Count register contents. If they contain a valid and supported block count value, that value is loaded for all subsequent Read and Write Multiple commands, and execution of those commands is enabled. An invalid and unsupported block count in the register results in an Aborted Command error and disallows Read Multiple and Write Multiple commands.

Write Commands

Write Sector(s)

Writes from 1 to 256 sectors, beginning at a sector specified in the Command Block. (A sector count of 0 requests 256 sectors.)

When the Command register is written, the drive sets the DRQ bit and waits for the host to fill the sector buffer with the data to be written. An interrupt is not generated to start the first buffer fill operation.

Once the buffer is full, the drive resets DRQ, sets BSY, and begins command execution. If the drive is not already on the desired track, an implied seek is performed.

The data loaded in the buffer is written to the data field of the sector, followed by the ECC bytes. Upon command completion, the Command Block registers contain the cylinder, head and sector number of the last sector written. The next time the buffer is ready to be filled during back-to-back Write Sector commands, DRQ is set and an interrupt is generated.

After the host fills the buffer, DRQ is reset and BSY is set. If an error occurs, Write Sector operations terminate at the sector containing the error.

The Command Block registers then contain the numbers of the cylinder, head and sector where the error occurred. The host may read the Command Block to determine the nature of that error, and on which sector it happened. A Write Long may be executed by setting the Long bit in the command code. The Write Long command writes the data and the ECC bytes directly from the sector buffer; the drive itself does not generate the ECC bytes. Restrict Write Long commands to PIO Mode 0.

Write Verify Sector(s)

Identical to the Write Sector(s) command, except that the requested sectors are verified immediately after being written. The verify operation reads (without transferring), and checks for data errors. Any errors encountered during this operation are reported.

Write Sector Buffer

Allows the host to overwrite the contents of the drive's sector buffer with a selected data pattern. When this command is received, the drive:

1. Sets BSY,
2. Sets up the sector buffer for a write operation,
3. Sets DRQ,
4. Resets BSY and
5. Generates an interrupt.

The host may then write up to 256 words of data to the buffer. A disk write task begins to store the host data to disk. Host write commands continue to be accepted and data transferred to the buffer until either the write command stack is full or the data buffer is full. The drive may reorder write commands to optimize drive throughput.

Write Multiple

Performs similarly to the Write Sector(s) command, except that:

1. The controller sets BSY immediately upon receipt of the command,
2. Data transfers are multiple sector blocks and
3. The Long bit and Retry bit is not valid.

Command execution differs from Write Sector(s) because:

1. Several sectors transfer to the host as a block without intervening interrupts.
2. DRQ qualification of the transfer is required at the start of the block, not on each sector.

The block count consists of the number of sectors to be transferred as a block and is programmed by the Set Multiple Mode command, which must be executed prior to the Write Multiple command. When the Write Multiple command is issued, the Sector Count register contains the number of sectors requested — not the number of blocks or the block count.

If the number of sectors is not evenly divisible by the block count, as many full blocks as possible are transferred, followed by a final, partial block transfer. This final, partial block transfer is for N sectors, where N = (sector count) modulo (block count)

The Write Multiple operation will be rejected with an Aborted Command error if attempted:

1. Before the Set Multiple Mode command has been executed, or
2. When Write Multiple commands are disabled.

All disk errors encountered during Write Multiple commands report after the attempted disk write of the block or partial block in which the error occurred.

The write operation ends with the sector in error, even if it was in the middle of a block. When an error occurs, subsequent blocks are not transferred. When DRQ is set at the beginning of each full and partial block, interrupts are generated.

Write DMA

Multi-word DMA

Identical to the Write Sector(s) command, except that:

1. The host initializes a slave-DMA channel prior to issuing the command,
2. Data transfers are qualified by DMARQ and are performed by the slave-DMA channel and
3. The drive issues only one interrupt per command to indicate that data transfer has terminated at status is available.

Ultra DMA

With the Ultra DMA Write protocol, the control signal (HSTROBE) that latches data from DD(15:0) is generated by the devices which drives the data onto the bus. Ownership of DD(15:0) and this data strobe signal are given to the host for an Ultra DMA data out burst.

During an Ultra DMA Write burst, the host always moves data onto the bus, and, after a sufficient time to allow for propagation delay, cable settling, and setup time, the sender shall generate a HSTROBE edge to latch the data. Both edges of HSTROBE are used for data transfers.

Any error encountered during Write DMA execution results in the termination of data transfer. The drive issues an interrupt to indicate that data transfer has terminated and status is available in the error register. The error posting is the same as that of the Write Sector(s) command.

Set Feature Commands

Set Features Mode

Enables or disables features supported by the drive. When the drive receives this command it:

1. Sets BSY,
2. Checks the contents of the Features register,
3. Clears BSY and
4. Generates an interrupt.

If the value of the register is not a feature supported by the drive, the command is aborted. The acceptable values in the Features register are defined as follows:

VALUE	DESCRIPTION
02h*	Enabled write cache
03h	Set transfer mode based on value in Sector Count register
44h	Length of data appended on Read Long/Write Long commands specified in the Identify Device information
55h	Disable read look-ahead feature
66h*	Disable reverting to power-on defaults
82h	Disable write cache
AAh*	Enable read look-ahead feature
BBh*	4 bytes of Maxtor specific data appended on Read Long/Write Long commands
CCh	Enable reverting to power-on defaults
* Enabled at power up by default.	

Power Mode Commands

Standby Immediate – 94h/E0h

Spin down and do not change time out value. This command will spin the drive down and cause the drive to enter the STANDBY MODE immediately. If the drive is already spun down, the spin down sequence is not executed.

Idle Immediate – 95h/E1h

Spin up and do not change time out value. This command will spin up the spin motor if the drive is spun down, and cause the drive to enter the IDLE MODE immediately. If the drive is already spinning, the spin up sequence is not executed. The actuator is parked and some circuits are powered off.

Standby – 96h/E2h

Spin down and change time out value. This command will spin the drive down and cause the drive to enter the STANDBY MODE immediately. If the drive is already spun down, the spin down sequence is not executed. A non-zero value placed in the sector count register will enable the Automatic Power Down sequence. The timer will begin counting down when the drive returns to the IDLE MODE. A value of zero placed in the sector count register will disable the Automatic Power Down sequence.

Idle – 97h/E3h

Spin up and change time out value. This command will spin-up the spin motor if the drive is spun-down. If the drive is already spinning, the spin up sequence is not executed. A non-zero value placed in the Sector Count register will enable the Automatic Power Down sequence and their timer will begin counting down immediately. A value of zero placed in the Sector Count register will disable the Automatic Power Down sequence. The actuator is parked and some circuits are powered off.

Check Power Mode – 98h/E5h

This command returns a code in the Sector Count register that determines the current Power Mode status of the drive. If the drive is in, going to, or recovering from the STANDBY MODE the drive sets the Sector Count register to OOh. If the drive is in the IDLE MODE or ACTIVE MODE, the drive sets the Sector Count register to FFh.

Set Sleep Mode – 99h/E6h

This command will spin the drive down and cause the drive to enter the SLEEP MODE immediately. If the drive is already spun down, the spin down sequence is not executed.

Note: The only way to recover from SLEEP MODE is with a software reset or a hardware reset.

Default Power-on Condition

The drive's default power on condition is the ACTIVE MODE.

Upon receiving a Power Mode command, except the SLEEP MODE command, the drive sets BSY and performs the requested power operation. Once the requested Power Mode change has begun, the drive resets BSY and generates an interrupt - without waiting for the drive to spin up or spin down. Upon receiving a SLEEP MODE command the drive is spun down, and when it is stopped, the drive resets BSY and generates an interrupt.

When enabling the Automatic Power Down sequence, the value placed in the Sector Count register is multiplied by five seconds to obtain the Time-out Interval value. If no drive commands are received from the host within the Time-out Interval, the drive automatically enters the STANDBY mode. The minimum value is 5 seconds.

TIMER VALUE	TIME-OUT PERIOD
0	Time-out disabled
1 - 240	(value * 5) seconds
241 - 251	((value - 240) * 30) minutes
252	21 minutes
253	Vendor unique period = 10 hours
254	Reserved
255	21 minutes, 15 seconds

While the drive is in STANDBY MODE, any commands received from the host are accepted and executed as they would in normal operation, except that the spin motor is started if required to execute a disk command. Under these conditions, the drive will set BSY when command processing would normally begin and will leave BSY set until the drive comes up to speed and the disk command can be executed. Disk commands issued while the drive is in STANDBY MODE, restarts the Time-out Interval after completing the command. A reset must be issued before attempting to issue any commands while the drive in SLEEP MODE.

Initialization Commands

Identify Drive

Allows the host to receive parameter information from the drive. When the command is received, the drive:

1. Sets BSY,
2. Stores the required parameter information in the sector buffer,
3. Sets the DRQ bit and
4. Generates an interrupt.

The host may then read the information out of the sector buffer. Parameter words in the buffer follow. Note that all reserved bits or words should be zeroes.

WORD	CONTENT DESCRIPTION
0	General configuration
	15 = device (0 = ATA, 1 = ATAPI)
	14-8 = not used
	7, 1 = removable media data
	6, 1 = not removable controller and/or device
	5-1 = reserved
	0
1	Number of cylinders
2	Reserved
3	Number of logical heads
4-5	Not used
6	Number of logical sectors per track
7-9	Not used
10 - 19	Drive serial number (40 ASCII characters)
20	Not used
21	Buffer size in 512 byte increments (0000h = not specified)
22	Number of Maxtor specific bytes available on Read/Write Long commands
23 - 26	Firmware revision (8 ASCII characters)
27 - 46	Model number (40 ASCII characters)
47	Maximum number of sectors that can be transferred per interrupt on read and write multiple commands
48	Reserved
49	Capabilities
	15 - 14 = reserved
	13 = standby timer (1 = values as specified in this standard are supported, 0 = values are Maxtor specific)
	12 = reserved (advanced PIO mode support)
	11, 1 = IORDY supported, 0 = IORDY may be supported
	10, 1 = IORDY can be disabled
	9-8 = reserved
	7-0 = not used

WORD	CONTENT DESCRIPTION
50	Reserved
51	15-8 = PIO data transfer mode
	7-0 = not used
52	15-8 = DMA data transfer mode
	7-0 = not used
53	15 = reserved 2, 1 = the fields supported in words 88 are valid, 0 = the fields supported in words 88 are not valid
	1, 1 = the fields reports in words 64-70 are valid, 0 = the fields reports in words 64-70 are not valid
	0, 1 = the fields reports in words 54-58 are valid, 0 = the fields reports in words 54-58 are not valid
54	Number of current logical cylinders
55	Number of current logical heads
56	Number of logical sectors per track
57 - 58	Current capacity in sectors
59	15-9 = reserved
	8, 1 = multiple sector setting is valid
	7-0xxh = current setting for number of sectors that can per transferred per interrupt on Read/Write Multiple command
60 - 61	Total number of user addressable sectors (LBA mode only)
62	Reserved
63	15-8 = Multi-word DMA transfer mode active
	7-0 = Multi=word DMA transfer modes supported
64	15-8 = reserved
	7-0 = advanced PIO transfer modes supported
65	Minimum multi-word DMA transfer cycle time (15-0 = cycle time in nanoseconds)
66	Manufacturer's recommeded multi-word DMA transfer cycle time (15-0 = cycle time in nanoseconds)
67	Minimum PIO transfer cycle time without flow control (15-0 = cycle time in nanoseconds)
68	Minimum PIO transfer cycle time with IORDY flow control (15-0 = cycle time in nanoseconds)
69-79	Reserved
80	15-5 = reserved
	4, 1 = supports ATA-4
	3, 1 = supports ATA-3
	2, 1 = supports ATA-2
	1, 1 = supports ATA-1 0, reserved
81	Minor version number
82	Command set supported. If words 82 and 83 = 0000h or FFFFh command set notification not supported.
	15, 1 = supports the Identify Device DMA command
	14, 1 = supports the NOP command
	13, 1 = supports the Write Buffer command
	12, 1 = supports the Read Buffer command
	11, 1 = supports the Read Buffer command
	10, 1 = supports Host-Protected Area feature set
	9, 1 = supports the Device Reset command
	8, 1 = supports Service Interupt
	7, 1 = supports Release Interupt
	6, 1 = supports Look Ahead
	5, 1 = supports Write Cache
	4, 1 = supports the Packet command feature set
	3, 1 = supports the Power Management feature command
	2, 1 = supports the Removable feature command
	1, 1 = supports the Security featurecommand
	0, 1 = supports the SMART feature set

WORD	CONTENT DESCRIPTION
83	Command sets supported. If words 82, 83 and 84 = 0000h or FFFFh command set notification not supported. 15 = shall be cleared to zero 14 = shall be set to one 13-1 = reserved 0, 1 = supports Download Microcode command
84	Command set extensions supported. If words 84, 85 and 86 = 0000h or FFFFh command set notification not supported. 15 = shall be cleared to zero 14 = shall be set to one 13-0 = reserved
85	Command set enabled. If words 84, 85 and 86 = 0000h or FFFFh command set notification not supported. 15, 1 = Identify Device DMA command enabled 14, 1 = NOP command enabled 13, 1 = Write Buffer command enabled 12, 1 = Read Buffer command enabled 11, 1 = Write Verify command enabled 10, 1 = Host Protected Area feature set enabled 9, 1 = Device Reset command enabled 8, 1 = Service Interrupt enabled 7, 1 = Release Interrupt enabled 6, 1 = Look Ahead enabled 5, 1 = Write Cache enabled 4, 1 = Packet command feature set enabled 3, 1 = Power Mangement feature set enabled 2, 1 = Removable feature set enabled 1, 1 = Security feature set enabled 0, 1 = SMART feature set enabled
86	Command sets enabled. If words 85, 86 and 87 = 0000h or FFFFh command set notification not supported. 15 = shall be cleared to zero 14 = shall be set to one 13-1 = reserved 0, 1 = supports Download Microcode command
87	Command sets enabled. If words 85, 86 and 87 = 0000h or FFFFh command set notification not supported. 15 = shall be cleared to zero 14 = shall be set to one 13-0 = reserved
88	Ultra DMA 15-11 Reserved 10 1 = Ultra DMA Mode 2 is selected 9 1 = Ultra DMA Mode 1 is selected 8 1 = Ultra DMA Mode 0 is selected 7-3 Reserved 2 1 = Ultra DMA Modes 2 and below are supported 1 1 = Ultra DMA Modes 1 and below are supported 0 = Ultra DMA Mode1 is not supported 0 1 = Ultra DMA Modes 0 is supported 0 = Ultra DMA Mode 0 is not supported
127	Reserved
128	Security Status 15-9 Reserved 8 Security Level 0 = High, 1 = Maximum 7-5 Reserved 4 1 = Security count expired 3 1 = Security frozen 2 1 = Security locked 1 1 = Security enabled 0 1 = Security supported
129-130	Reserved
131	Spin at power-up, but 0 is asserted when no spin at power-up is enabled.
132-159	Maxtor-specific (not used)
160-255	Reserved

Initialize Drive Parameters

Enables the drive to operate as any logical drive type. The drive will always be in the translate mode because of Zone Density Recording, which varies the number of sectors per track depending on the zone.
Through setting the Sector Count Register and Drive Head Register, this command lets the host alter the drive's logical configuration. As a result, the drive can operate as any equal to or less than capacity drive type. Do not exceed the total number of sectors available on the drive:

When this command is executed, the drive reads the Sector Counter Register and the Drive Head Register (and so determines the number of the logical sectors per track and maximum logical head number per cylinder and will calculate the number of logical cylinders.)

Upon receipt of the command, the drive:

1. Sets BSY,
2. Saves the parameters,
3. Resets BSY and
4. Generates an interrupt.

To specify maximum heads, write 1 less than the maximum (e.g. write 4 for a 5 head drive). To specify maximum sectors, specify the actual number of sectors (e.g. 17 for a maximum of 17 sectors/track).

The sector count and head values are not checked for validity by this command. If they are invalid, no error will be posted until an illegal access is made by some other command.

Moves the read/write heads from anywhere on the disk to cylinder 0.
When this command is received, the drive:

1. Sets BSY and
2. Issues a seek to cylinder zero.

The drive waits for the seek to complete, then the drive:

1. Updates status,
2. Resets BSY and
3. Generates an interrupt.

If the drive cannot reach cylinder 0, the Error bit is set in the Status register, and the Track 0 bit is set in the Error register.

NOTE: If a maximum head and sector number is selected – such that the number of cylinders will exceed 65,535 – then the maximum cylinder value will be reduced to 65, 535.

Seek, Format and Diagnostic Commands

Seek

Initiates a seek to the track, and selects the head specified in the Command block.

1. Sets BSY in the Status register,
2. Initiates the Seek,
3. Resets BSY and
4. Generates an interrupt.

The drive does not wait for the seek to complete before returning the interrupt. If a new command is issued to a drive during the execution of a Seek command, the drive will wait (with BSY active) for the Seek to complete before executing the new command.

Format Track

Formats the track specified in the Command Block. Shortly after the Command register is written, the drive sets the bit, and waits for the host to fill the sector buffer with the interleave table. When the buffer is full, the drive resets DRQ, sets BSY and begins command execution. If the drive is not already on the desired track, an implied seek is performed. Once at the desired track the data fields are written with all zeroes.

Execute Drive Diagnostic

Commands the drive to implement the internal diagnostic tests. (These tests are executed only upon command receipt; they do not run automatically at power up or after a reset.)

The drive sets BSY immediately upon receiving this command. The following table presents the codes and their descriptions. Note that the value in the Error register should be viewed as a unique 8 bit Code.

ERROR CODE	DESCRIPTION
01	No error detected
00	Master drive failed
80, 82	Master and slave drives failed
81	Slave drive failed

Note: If a slave drive fails diagnostics, the master drive OR's 80h with its own status, and loads that code into the Error register. If a slave drive passes diagnostics (or a slave is absent), the master drive OR's 00 with its own status and loads that code into the Error register.

S.M.A.R.T. Command Set

Execute S.M.A.R.T.

The Self-Monitoring Analysis and Reporting Technology (S.M.A.R.T.) command has been implemented to improve the data integrity and data availability of hard disk drives. In some cases, a S.M.A.R.T. capable device will predict an impending failure with sufficient time to allow users to backup their data and replace the drive before data loss or loss of service.

The S.M.A.R.T. sub-commands (listed below) comprise the ATA S.M.A.R.T. feature set that provide access to S.M.A.R.T. attribute values, attribute thresholds and other logging and reporting information.

Prior to writing a S.M.A.R.T. command to the device's command register, key values must be written by the host into the device's Cylinder Low and Cylinder High registers, or the command will be aborted. For any S.M.A.R.T. sub-command, if a device register is not specified as being written with a value by the host, then the value in that register is undefined and will be ignored by the device. The key values are:

Key	Register
4Fh	Cylinder Low (1F4h)
C2h	Cylinder High (1F5h)

The S.M.A.R.T. sub-commands use a single command code (B0h) and are differentiated from one another by the value placed in the Features register. In order to issue a command, the host must write the sub-command-specific code to the device's Features register before writing the command code to the command register. The sub-commands and their respective codes are:

D0h S.M.A.R.T. Read Attribute Value
This feature returns 512 bytes of attribute information to the host.

D1h S.M.A.R.T. Read Attribute Thresholds
This feature returns 512 bytes of warranty failure thresholds to the host.

D2h Enable/Disable Autosave
To enable this feature, set the sector count register to F1h (enable) or 0 (disable). Attribute values are automatically saved to non-volatile storage on the device after five minutes of idle time and before entering idle, sleep or standby modes. This feature is defaulted to "enabled" when S.M.A.R.T. is enabled via the S.M.A.R.T. Enable Operations commands. The autosave feature will not impact host system performance and does not need to be disabled.

D3h S.M.A.R.T. Save Attribute Value
This feature saves the current attribute values to non-volatile storage.

D4h Perform Off-Line Data Collection
Data is collected from random seeks, timed pattern seek times and head margin tests.

D8h Enable S.M.A.R.T.

D9h Disable S.M.A.R.T.

DAh S.M.A.R.T. Return Status
This feature allows the host to assess the status of a S.M.A.R.T. capable device by comparing all saved attribute values with their corresponding warranty failure thresholds. If no thresholds are exceeded, the drive is declared to have a positive health status. If any warranty failure threshold is exceeded, the drive is declared to have a negative health status. Executing this sub-command results in all attribute values being saved to non-volatile storage on the device.

DBh Enable/Disable Automatic Off-Line
To enable this feature, set the Sector Count register to F1h or 0 to disable.

Service and Support

Service Policy

Repairs to any DiamondMax™ 4320 drive should be made only at an authorized Maxtor repair facility. Any unauthorized repairs or adjustments to the drive void the warranty.

To consistently provide our customers with the best possible products and services, Maxtor developed the Total Customer Satisfaction (TCS) program. Through the ongoing TCS process, Maxtor employees take direct responsibility for every customer's level of satisfaction – with Maxtor technology, price, quality, delivery, service and support.

No Quibble® Service

Another TCS feature is Maxtor's *No Quibble*® Service policy. By minimizing paperwork and processing, *No Quibble* Service dramatically cuts the turnaround time normally required for repairs and returns. Here's how it works:

1. Customer calls 1-800-2MAXTOR for a Return Material Authorization (RMA) number and provides a credit card number,
2. Maxtor ships a replacement drive within 2 business days, and
3. Customer returns the original drive and credit card draft is destroyed.

Support

Technical Assistance

Highly-trained technicians are available 6 a.m. to 6 p.m. (Mountain Standard Time) Monday through Friday to provide detailed technical support.

U.S. and Canada	Language support: English, Spanish
Voice	800-2MAXTOR, press 1 (800-262-9867)
E-mail	Technical_Assistance@maxtor.com
Fax	303-678-2260
Outside U.S. and Canada	303-678-2015
Europe	Language support: English, French, German
Voice	+ 353 1 204 11 11
E-mail	Eurotech_Assistance@maxtor.com
Fax	+ 353 1 286 14 19
Asia/Pacific	
Voice	Contact your local Maxtor Sales Office for assistance
E-mail	Apactech_Assistance@maxtor.com
	Language support: English

MaxInfo Service

Use a touch-tone phone to listen to technical information about Maxtor products and the top Q&A's from our 24-hour automated voice system.

U.S. and Canada	800-2MAXTOR (800-262-9867)
	Press 1, wait for announcement, listen for option
Outside U.S. and Canada	303-678-2015, listen for option

MaxFax™ Service

Use a touch-tone phone to order Technical Reference Sheets, Drive Specifications, Installation Sheets and other documents from our 24-hour automated fax retrieval system. Requested items are sent to your fax machine.

U.S. and Canada	Language support: English, Spanish
Phone	800-2MAXTOR, listen for option (800-262-9867)
Outside U.S. and Canada	303-678-2618
Europe	Language support: English, French, German
Phone	+ 353 1 204 11 22
Asia/Pacific	Language support: English
Phone	+ 61 2 9369 4733

Internet

Browse the Maxtor home page on Internet, download files from our FTP site.

Home Page	http://www.maxtor.com

Customer Service

All Maxtor products are backed by *No Quibble*® Service, the benchmark for service and support in the industry. Customer Service is available 7 a.m. to 6 p.m. (Pacific Standard Time) Monday through Friday.

U.S. and Canada	Language support: English, Spanish
Voice	800-2MAXTOR, press 2 (800-262-9867)
E-mail	RMA@maxtor.com
Fax	408-922-2085
Europe	Language support: English, French, German
Voice	+ 353 1 204 11 11
E-mail	Eurotech_Assistance@maxtor.com
Fax	+ 353 1 286 14 19
Asia/Pacific	Call Singapore Customer Service from the countries listed below. Customer Service is available 8 a.m. to 5:30 p.m. *(Singapore time is GMT +8).*

From	Dial
Australia	1-800-124-328
Hong Kong	+800-3387
Indonesia	+001-800-65-6500
Japan	+0031-65-3616
Korea	+088-65-800-6500
Malaysia	1-800-1126
New Zealand	+0800-44-6542
Singapore	1-800-481-6788
Taiwan	+0080-65-1062
Thailand	+001-800-65-6500

Glossary

A

ACCESS
To obtain data from, or place data into, RAM, a register, or data storage device.

ACCESS TIME
The interval between the issuing of an access command and the instant that the target data may be read or written. Access time includes seek time, latency and controller overhead time.

ADDRESS
A number, generally binary, distinguishing a specific member of an ordered set of locations. In disk engineering, the address may consist of drives (unit address), radial positions (cylinder address), or circumferential position (sector address).

ALLOCATION
A process of assigning designated areas of the disk to particular files.

ALTERNATE TRACK
A spare track used in the event that a normal track becomes damaged or is unusable.

ANALOG
A signal or system that does not use digital states to convey information. A signal may have any number of significant states (values), contrasted to digital signals which can only have two states.

ANSI
American National Standards Institute.

APPLICATION PROGRAM
A sequence of programmed instructions that tell the computer how to perform some end-user task, such as accounting or word processing.

AREAL DENSITY
Bit density (bits per inch) multiplied by track density (tracks per inch) or bits per square inch.

ASYMMETRY
A distortion of the readback signal which is shown in different intervals between the positive and negative voltage peaks.

AUXILIARY MEMORY
Memory other than main memory; generally a mass-storage subsystem containing disk drives and backup tape drives, controller(s) and buffer memory (also called peripheral memory).

AVERAGE ACCESS TIME
The average time to make all possible length accesses (seeks).

AVERAGE SEEK TIME
The average time to make all possible length seeks. A typical measure of performance.

B

BAD BLOCK
A block that cannot store data because of a media flaw.

BIT
An abbreviation for binary digit, of which there are two (0 and 1). A bit is the basic data unit of most digital computers. A bit is usually part of a data byte or word, but bits may be used singly to control or read logic "on-off" functions. The fundamental unit information, often used loosely to refer to a circuit or magnetization state at a particular instant in time.

BIOS
Acronym for Basic Input/Output System. The firmware area of a CPU that controls operations through the system bus and to the attached cards and peripheral devices.

BPI
Acronym for bits per inch. See bit density.

BLOCK
A group of bytes handled, stored, and accessed as a logical data unit, such as an individual file record.

BUFFER
A temporary data storage area that compensates for a difference in data transfer rates and/or data processing rates between sender and receiver.

BUS
A collection of functionally parallel conductors that forms an interconnection between functional blocks in a digital device. A length of parallel conductors that forms a major interconnection route between the computer system CPU (central processing unit) and its peripheral subsystems. Depending on its design, a bus may carry data, addresses, power, and more.

BYTE
An ordered collection of bits treated as a unit. Most often, a byte is understood to consist of eight bits. One byte is necessary to define an alphanumeric character.

C

CACHE
Random access memory (RAM) used as a buffer between the CPU and the disk drive.

CAPACITY
The amount of data, usually expressed in bytes, which can be stored in a given device or portion of same.

CENTRAL PROCESSING UNIT (CPU)
The heart of the computer system that executes programmed instructions. It includes the arithmetic logic unit (ALU) for performing all math and logic operations, a control section for interpreting and executing instructions, internal memory for temporary storage of program variables and other functions.

CHANNEL
A collection of electronic circuits used in the process of writing and reading information to and from magnetic media.

CHARACTER
An ordered collection of bits representing one of a set of predefined symbols. Often the term is used interchangeably with byte, but this is inexact.

CLOSED LOOP
A control technique that enables the positioning system to correct off-track errors in real time. The actual head position is monitored and compared to the ideal track position to determine any position error that might be occurring. This information is then used to produce a correction signal (feedback) that goes to the positioner to correct the error. (See also track following servo).

CLOSED LOOP SERVO
A servo control technique that uses position feedback to correct off-track errors. See Track Following Servo.

CLUSTER
The smallest allocatable unit of disk storage allowed by MS-DOS; each FAT entry represents one cluster.

CONTROLLER
An electronic device for connecting one or more mass storage peripherals (rigid disk drives, tape drives, and optical disk drives) to the input/output circuits of a host computer. Controllers vary in complexity, with more sophisticated units able to buffer and schedule commands, correct data errors, and bypass media defects without host intervention.

CONTROLLER
A miniature CPU dedicated to controlling a peripheral device, such as a disk drive, tape drive, video display terminal, or printer. The controller executes commands from the central processing unit and reissues commands to the peripheral device.

CORRECTABLE ERROR
An error that can be overcome by the use of Error Detection and Correction.

CYLINDER
On several disk surfaces sharing a common rotational axis, the aggregate of tracks at a given radial position. A set of disk tracks that are simultaneously under the set of read/write heads. This three-dimensional storage volume can be accessed after a single seek.

CYLINDER ZERO
The outermost cylinder in a drive that can be used for data storage.

D

DATA
An ordered collection of information. In a specific case, it is the information processed by a computer.

DATA SEPARATOR
An electronic circuit which decodes playback data and produces separate clock and data bits. Sometimes incorrectly used to denote data synchronizer.

DATA SYNCHRONIZER
An electronic circuit producing a clock signal that is synchronous with the incoming data stream. This clock signal is then used to decode the recording code being used into user data.

DATA TRANSFER RATE
In a disk or tape drive, the rate at which data is transferred to or from the storage media. It is usually given in thousands of bits per second (Kbit/second) or millions of bits per second (Mbit/second).

DEDICATED LANDING ZONE
A designated radial zone on the disk where contact starting and stopping occur by design.

DEDICATED SERVO
A servo scheme in which a prerecorded pattern on an otherwise unused disk surface provides position information to the servo circuitry by means of a head reading that surface.

DEFECT
A magnetic imperfection in a recording surface.

DEFECT MANAGEMENT
A general methodology of avoiding data errors on a recording surface by avoiding the use of known bad areas of media. Usually defective sectors or tracks are retired and data are written in alternate locations. Several algorithms are possible such as "sector slipping," or "spare sector per track."

DEFECT MAP
A list of defects that fall within a pass/fail criteria of a user. This list is usually used by an operating system or a disk drive controller for defect management.

DEFECT SKIPPING
A defect management scheme for avoiding surface defects. It has data written before and after the defect, instead of using alternate tracks or sectors to avoid use of the defective area.

DENSITY
Generally, recording density. See areal, bit, and storage density.

DC ERASE
The method of erasing a track using a DC write/erase current through either a Read/Write or Erase head.

DIGITAL
Any system that processes digital binary signals (having only values of a 1 or 0; usually in bits and bytes) rather than analog signals (signals that can have many values)

DIGITAL MAGNETIC RECORDING
See magnetic recording.

DIRECT ACCESS
Access directly to memory location. (See random access).

DIRECT MEMORY ACCESS
A mean of data transfer between the device and host memory without processor intervention.

DIRECTORY
A listing of files maintained by the disk operation system (DOS) or a data base management system to enable a user to quickly access data files.

DISK
A flat, circular piece of metal (usually aluminum) or plastic (usually mylar) with a magnetic coating upon which information can be recorded. (See, for example, floppy disk or Winchester disk)

DISK DRIVE OR DISK MEMORY DEVICE
The total electromechanical storage device containing disks and read/write heads, head positioning mechanism, drive motor, and electronics.

DISK PACK
A number of metal disks packaged in a canister for removal from the disk drive (predecessor of Winchester technology).

DISK OPERATING SYSTEM (DOS)
The master computer system program that schedules tasks, allocates the computer system resources, controls accesses to mass storage devices, manages files, and so forth. Typical disk operating systems include CP/M, MS-DOS, and UNIX.

DISK STORAGE
Auxiliary memory system containing disk drives.

DISK TRANSFER RATE
The rate that digital data is transferred from one point to another. Expressed in either bits/second or bytes/second.

DOUBLE FREQUENCY ENCODING
Another name for FM encoding. This is because all possible data combinations will result in only two possible temporal displacements of adjacent data bits, specifically "1F" and 2F."

E

EARLY WINDOW
A data window that has been intentionally shifted in time in an early direction.

EMBEDDED SERVO
A servo technique used for track following. Position information is prerecorded between data areas in a track so that a data head, and proper additional circuitry, can determine the data head location with respect to the center position of the track (or cylinder) in question.

ERASE
A process by which a signal recorded on a medium is removed and the medium made ready for rerecording.

ERROR CORRECTION CODE (ECC)
A mathematical algorithm that can detect and correct errors in a data field. This is accomplished with the aid of Check Bits added to the raw data.

ERROR FREE
A recording surface that has no defects.

ERROR RATE
The number of errors (type must be specified) that occur in a specified number of bits read.

ERROR RECOVERY PROCEDURE
The process that occurs in response to a data error. In a drive without ECC, this would include re-calibration and re-seeking to the specified track and rereading the specified data.

EXTRA PULSE
Term used in surface certification. It is when a flux field discontinuity remains after the recording surface is erased, thereby producing an electrical output of a read head passing over the area with the discontinuity. An extra pulse occurs when the electrical output is larger than a specified threshold.

F

FEEDBACK
In a closed-loop system, the output signal (from the servo head) is used to modify the input signal (to the positioner).

FETCH
A read operation and its related data transfer operations.

FILE ALLOCATION TABLE (FAT)
Allocates space on the disk for files, one cluster at a time; locks out unusable clusters; identifies unused (free) area; and lists a file's location. With two FAT's present, the second copy ensures consistency and protects against loss of data if one of the sectors on the first FAT is damaged.

FLUX CHANGES PER INCH
Synonymous with frpi (flux reversals per inch). Only in MFM recording does 1 fci equal 1 bpi (bit per inch). In run-length-limited encoding schemes, generally 1 fci equals 1.5 bpi.

FORMAT
In a disk drive, the arrangement of data on a storage media. A standard 5.25-inch disk format consists of 17, 26, or 36 sectors per track, and 512 bytes of data per sector, plus identification, error correction, and other bytes necessary for accessing and synchronizing data.

FORMATTED CAPACITY
The actual capacity available to store data in a mass storage device. The formatted capacity is the gross capacity, less the capacity taken up by the overhead data used in formatting the sectors.

FREQUENCY MODULATION
A recording code. A flux reversal at the beginning of a cell time represents clock bit; a "1" bit is a flux reversal at the center of the cell time, and a "0" bit is an absence of a flux reversal.

FREQUENCY RESPONSE
A measure of how effectively a circuit or device transmits the different frequencies applied to it. In disk and tape drives this refers to the read/write channel. In disk drives, it can also refer to the dynamic mechanical characteristics of a positioning system.

G

GIGABYTE (GB)
One billion bytes (one thousand megabytes) or 10^9.

H

HARD ERROR
An error that is not able to be overcome by repeated readings and repositioning means.

HARD SECTORED
A technique where a digital signal indicates the beginning of a sector on a track. This is contrasted to soft sectoring, where the controller determines the beginning of a sector by the reading of format information from the disk.

HEAD
The electromagnetic device that write (records), reads (plays back), and erases data on a magnetic media. It contains a read core(s) and/or a write core(s) and/or erase core(s) which is/are used to produce or receive magnetic flux. Sometimes the term is all inclusive to mean the carriage assembly which includes the slider and flexure.

HEAD CRASH
The inadvertent touching of a disk by a head flying over the disk (may destroy a portion of the media and/or the head).

HEAD DISK ASSEMBLY (HDA)
The mechanical portion of a rigid, fixed disk drive. It usually includes disks, heads, spindle motor, and actuator.

HEAD LOADING ZONE
The non-data area on the disk set aside for the controlled takeoff and landing of the Winchester heads when the drive is turned on and off. Dedicated annulus on each disk surface in which heads are loaded, unloaded, or flying height is established. Head-disk contact may occur in some instances; no data is recorded in this area.

HEAD POSITIONER
Also known as actuator, a mechanism that moves the arms that carry read/write heads to the cylinder being accessed.

I

INDEX
Similar to a directory, but used to establish a physical to logical cross reference. Used to update the physical disk address (tracks and sectors) of files and to expedite accesses.

INSIDE DIAMETER
The smallest radial position used for the recording and playback of flux reversals on a magnetic disk surface.

INITIALIZATION
Applying input patterns or instructions to a device so that all operational parameters are at a known value.

INPUT
Data entering the computer to be processed; also user commands.

INPUT/OUTPUT (I/O)
The process of entering data into or removing data from a computer system or a peripheral device.

INTELLIGENT PERIPHERAL
A peripheral device that contains a processor or microprocessor to enable it to interpret and execute commands.

INTERFACE
The data transmitters, data receivers, logic, and wiring that link one piece of computer equipment to another, such as a disk drive to a controller or a controller to a system bus.

INTERFACE STANDARD
The interface specifications agreed to by various manufacturers to promote industry-wide interchangeability of products such as a disk drive. Interface standards generally reduce product costs, allows buyers to purchase from more than one source, and allow faster market acceptance of new products.

INTERLEAVE
An ordering of physical sectors to be skipped between logical sectors on your hard disk.

I/O PROCESSOR
Intelligent processor or controller that handles the input/output operations of a computer.

INTERRUPT
A signal, usually from a subsystem to a central processing unit, to signify that an operation has been completed or cannot be completed.

J

JUMPER
A small piece of plastic that slides over pairs of pins that protrude from the circuit board on the hard drive to make an electrical connection and activate a specific option.

K

KILOBYTE (KB)
A unit of measure of approximately 1,000 bytes. (However, because computer memory is partitioned into sizes that are a power of two, a kilobyte is really 1,024 bytes.)

L

LANDING ZONE OR LZONE
The cylinder number to where ParkHeads move the read/write heads.

LATE BIT
A bit that is in the late half of the data window.

LATE WINDOW
A data window that has been shifted in a late direction to facilitate data recovery.

LATENCY
A delay encountered in a computer when waiting for a specific response. In a disk drive there is both seek latency and rotational latency. The time required for the addressed sector to arrive under the head after the head is positioned over the correct track. It is a result of the disk's rotational speed and must be considered in determining the disk drive's total access time.

LOGIC
Electronic circuitry that switches on and off ("1" and "0") to perform functions.

LOGICAL ADDRESS
A storage location address that may not relate directly to a physical location. Usually used to request information from a controller, which performs a logical to physical address conversion, and in turn, retrieves the data from a physical location in the mass storage peripheral.

LOGICAL BLOCK ADDRESSING
Defines the addressing of the device by the linear mapping of sectors.

LOGICAL SECTOR
The lowest unit of space that DOS can access through a device driver; one or more physical sectors.

LOW FREQUENCY
The lowest recording frequency used in a particular magnetic recording device. With FM or MFM channel codes, this frequency is also called "IF."

M

MAIN MEMORY
Random-access memory (RAM) used by the central processing unit (CPU) for storing program instructions and data currently being processed by those instructions. (See also random access memory.)

MASS STORAGE
Auxiliary memory used in conjunctions with main memory; generally having a large, on-line storage capacity.

MEGABYTE (MB)
A unit of measure approximately one million bytes (actually 1,048,576 bytes) or 10^6.

MEMORY
Any device or storage system capable of storing and retrieving information. (See also storage definitions.)

MICROCOMPUTER
A computer whose central processing unit is a microprocessor. It is usually, but not necessarily, desktop size.

MICROPROCESSOR
A central processing unit (CPU) manufactured as a chip or a small number of chips.

MISSING PULSE
A term used in surface certification. It is when a prerecorded signal is reduced in amplitude by a certain specified percentage.

MODIFIED FREQUENCY MODULATION (MFM)
A method of encoding digital data signals for recording on magnetic media. Also called "three frequency recording." Recording code that only uses synchronizing clock pulse if data bits are not present. Doubles the lineal bit density without increasing the lineal flux reversal density, compared to Frequency Modulation.

MODIFIED MODIFIED FREQUENCY MODULATION (MMFM)
A recording code similar to MFM that has a longer run length limited distance.

MODULATION
1. Readback voltage fluctuation usually related to the rotational period of a disk. 2. A recording code, such as FM, MFM, or RLL, to translate between flux reversals and bits or bytes.

N

NON-RETURN TO ZERO
A form of data encoding that is not self-clocking, in other words, it needs to be provided with an external bit cell clock signal. Generally used in higher-performance disk drives.

O

OFF-LINE
processing or peripheral operations performed while disconnected from the system CPU via the system bus.

ON-LINE
processing or peripheral operations performed while disconnected from the system CPU via the system bus.

OPEN LOOP SERVO
A head positioning system that does not use positional information to verify and correct the radial location of the head relative to the track. This is usually achieved by use of a stepper motor which has predetermined stopping point that corresponds to track locations.

OPERATING SYSTEM
A software program that organizes the actions of the parts of the computer and its peripheral devices. (See disk operating system.)

OUTSIDE DIAMETER
The largest radius recording track on a disk.

OVERWRITE
A test that measures the residual 1F recorded frequency on a track after being overwritten by a 2F signal. Variations of the test exist.

P

PARALLELISM
1. The condition of two planes or lines being parallel. Important in disk drives because a lack of it in mechanical assemblies can result in positioning inaccuracy. More precisely: planes-coplanar; lines-colinear. 2. Is the local variation in disk thickness measured independently of thickness itself. 3. The ability of a multiprocessor computer to allocate more than one processor (CPU) to a computing problem, where each CPU works on a separate problem or separate segment of that problem. Also referred to as parallel processing.

PARITY
A simple method of data error detections that always makes numbers either odd or even, using an extra bit in which the total number of binary 1s (or 0s) in a byte is always odd or always even; thus, in an odd parity scheme, every byte has eight bits of data and one parity bit. If using odd parity and the number of 1 bits comprising the byte of data is not odd, the ninth or parity bit is set to 1 to create the odd parity. In this way, a byte of data can be checked for accurate transmission by simply counting the bits for an odd parity indication. If the count is ever even, an error is indicated.

PARTITION
A logical section of a disk drive, each of which becomes a logical device with a drive letter.

PEAK SHIFT
The shifting in time of the zero-slope portion of a readback voltage from the values contained in the write current waveform. Sometimes incorrectly used to describe bit jitter.

PERIPHERAL EQUIPMENT
Auxiliary memory, displays, printers, and other equipment usually attached to a computer system's CPU by controllers and cables. (They are often packaged together in a desktop computer.)

PHASE LOCKED LOOP (PLL)
A circuit whose output locks onto and tracks the frequency of an input signal. Sometimes incorrectly called a data separator.

PHASE MARGIN
Measure in degrees of the amount of difference between excursions from the window center where flux reversals can occur and the edge of the data window. Similar to window margin.

PHYSICAL SECTOR
The smallest grouping of data on the hard disk; always 512 bytes.

PIO
Programmable Input Output. A means of accessing device registers. Also describes one form of data transfers. PIO data transfers are performed by the host processor using PIO register accesses to the data register.

PLATED THIN FILM MEDIA
Magnetic disk memory media having its surface plated with a thin coating of a metallic alloy instead of being coated with oxide.

PROCESSING
The process of the computer handling, manipulating and modifying data such as arithmetic calculation, file lookup and updating, and word pressing.

PULSE CROWDING
Modification of playback amplitude due to super-positioning of adjacent flux reversal fields being sensed by the read/write gap.

PULSE DETECT
A digital pulse train in which each leading edge or each edge corresponds to a magnetic transition read from the disk. If transition qualification circuitry exists in the drive, this signal is the output of same. Also known as transition detect.

R

RANDOM ACCESS MEMORY (RAM)
Memory designed so that any storage location can be accessed randomly, directly and individually. This is contrasted to sequential access devices such as tape drives.

READ
To access a storage location and obtain previously recorded data. To sense the presence of flux reversals on magnetic media. Usually implemented such that a dynamic flux amplitude will cause a proportional electrical output from the transducer.

READ GATE SIGNAL
A digital input signal which causes the drive circuitry to recover data.

READ ONLY MEMORY (ROM)
A form of memory which cannot be changed in formal operational modes. Many different types are available. RAM is used for permanent information storage. Computer control programs are often stored in ROM applications.

READ/WRITE HEAD
The recording element which writes data to the magnetic media and reads recorded data from the media.

RE-CALIBRATE
The action of moving the head of a disk drive to cylinder zero.

RECOVERABLE ERROR
A read error, transient or otherwise, falling within the capability of an ECC mechanism to correct, or able to overcome by rereading the data in question.

ROTATIONAL LATENCY
The amount of delay in obtaining information from a disk drive attributable to the rotation of the disk.

RUN-LENGTH LIMITED
An encoding process that repositions data bits and limits the length of zero bits in order to compress information being stored on disks.

RUN-LENGTH LIMITED ENCODING
A recording code. Sometimes meant to denote "2.7 RLL" which can signify 1.5 times the bits as MFM, given the same number of flux reversals in a given lineal distance.

S

SECTOR
A logical segment of information on a particular track. The smallest addressable unit of storage on a disk. Tracks are made of sectors.

SECTOR PULSE SIGNAL
A digital signal pulse present in hard sectored drives which indicates the beginning of a sector. Embedded servo pattern or other prerecorded information may be present on the disk when sector is active.

SEEK
A random access operation by the disk drive. The act of moving a set of read/write heads so that one of them is over the desired cylinder. The actuator or positioner moves the heads to the cylinder containing the desired track and sector.

SEEK COMPLETE SIGNAL
A digital signal level which indicates that the positioner is not moving and is located over a cylinder or offset position.

SEEK TIME
The amount of time between when a step pulse or seek command is issued until the head settles onto the desired cylinder. Sometimes is measured without settling times.

SEQUENTIAL ACCESS
The writing or reading of data in a sequential order such as reading data blocks stored one after the other on magnetic tape. This is contrasted to random access of information.

SERVO BURST
A momentary servo pattern used in embedded servo control systems usually positioned between sectors or at the end of a track.

SERVO CONTROL
A technique by which the speed or position of a moving device is forced into conformity with a desired or standard speed or position.

SERVO HEAD
A magnetic head designed specifically for accurately reading servo data.

SERVO PATTERN
A readback signal that indicates the position of a head relative to a track.

SERVO SURFACE
A recording surface in a multi-surface disk drive that only contains control information which provides timing, head position, and track-following information for the data surfaces.

SERVO SYSTEM
An automatic system for maintaining the read/write head on track; can be either "open loop," "quasi-closed loop," or "closed loop."

SERVO TRACK
A track on a servo surface. The prerecorded reference track on the dedicated servo surface of a disk drive. All data track positions are compared to their corresponding servo track to determine "off track"/"on track" position.

SETTLING TIME
The time it takes a head to stop vibrating, within specified limits, after it reaches the desired cylinder.

SILICON
Semiconductor material generally used to manufacture microprocessors and other integrated circuit chips.

SMALL COMPUTER SYSTEM INTERFACE (SCSI)
An intelligent interface that incorporates controller functions directly into the drive.

S.M.A.R.T. CAPABILITY
Self-Monitoring Analysis and Reporting Technology. Prediction of device degradation and/or faults.

SOFT ERROR
A data error which can be overcome by rereading the data or repositioning the head.

SOFT SECTORED
A technique where the controller determines the beginning of a sector by the reading of format information from the disk. This is contrasted to hard sectoring where a digital signal indicates the beginning of a sector on a track.

SOFTWARE
Applications programs, operating systems, and other programs (as opposed to hardware).

SPINDLE
The rotating hub structure to which the disks are attached.

SPINDLE MOTOR
The motor that rotates the spindle and therefore the disks.

SPUTTERED MEDIA
Magnetic disk or tape that has the magnetic layer deposited by sputtering means.

STEPPER MOTOR
A motor that has known detent positions where the rotor will stop with the proper control in some cases. The digitally controlled motor moves the head positioner from track to track in small, step-like motions.

STORAGE CAPACITY
The amount of data that can be stored in a memory location, usually specified in kilobytes for main memory and floppy drives and megabytes for mass storage devices.

STORAGE DENSITY
Usually refers to recording density (BPI, TPI, or a combination of the two.)

STORAGE LOCATION
A memory location, identified by an address where information may be read or written.

STROBE OFFSET SIGNAL
A group of digital input signal levels which cause the read PLL and/or data decoder to shift the decoding windows by fractional amounts. Often early/late are modified when two signals are used.

T

THIN-FILM HEAD
A magnetic transducer manufactured by deposition of magnetic and electrical materials on a base material contrasted with prior art mechanical methods. Read/write heads whose read/write element is deposited using integrated circuit techniques rather than being manually wound.

THIN-FILM MEDIA
See plated thin film media.

TRACK
One surface of a cylinder. A path which contains reproducible information left on a magnetic medium by recording means energized from a single channel.

TRACK-FOLLOWING SERVO
A closed-loop positioner control system that continuously corrects the position of the disk drive's heads by utilizing a reference track and a feedback loop in the head positioning system. (See also closed loop.)

TRACKS PER INCH (TPI)
A measurement of radial density. Tracks per inch of disk radius.

TRACK POSITIONING
The method, both mechanical and electrical, used to position the heads over the correct cylinder in a disk drive system.

U

UN-CORRECTABLE ERROR
An error that is not able to be overcome with Error Detection and Correction.

UNFORMATTED CAPACITY
Storage capacity of disk drive prior to formatting; also called the gross capacity. (See format.) The raw capacity of a drive not taking into account the capacity loss due to storage of the format control information on the disk surfaces.

UNRECOVERABLE ERROR
A read error falling outside the capability of an ECC mechanism to correct, or not able to be overcome by rereading the data in question, with or without repositioning the head.

V

VOICE COIL MOTOR
A positioning motor that uses the same principle as a voice coil in a loudspeaker. The motor has no detent positions. The mechanical motion output of it can be either rotary or linear.

W

WHITNEY HEAD
A successor to the original Winchester read/write head design. The primary change was to make the flexure smaller and more rigid. First used in IBM 3370/3380.

WHITNEY TECHNOLOGY
A method of constructing a read/write head in a rigid disk drive using a Whitney head. In all other details it is the same as Winchester technology.

WINCHESTER HEAD
The read/write head used in Winchester technology, non-removable media disk drives. May be either a monolithic or composite type. It is aerodynamically designed to fly within microinches of the disk surface.

WINCHESTER TECHNOLOGY
A method of constructing a rigid disk drive using concepts introduced in the IBM model 3340 disk drive. The primary changes from prior technology was to lower the mass of the slider, use of a monolithic slider, radically changing the design of the flexure and having the slider come to rest on a lubricated disk surface when disk rotation ceases. In addition to the above, a totally sealed chamber containing the read/write heads and disks was used to protect against contamination.

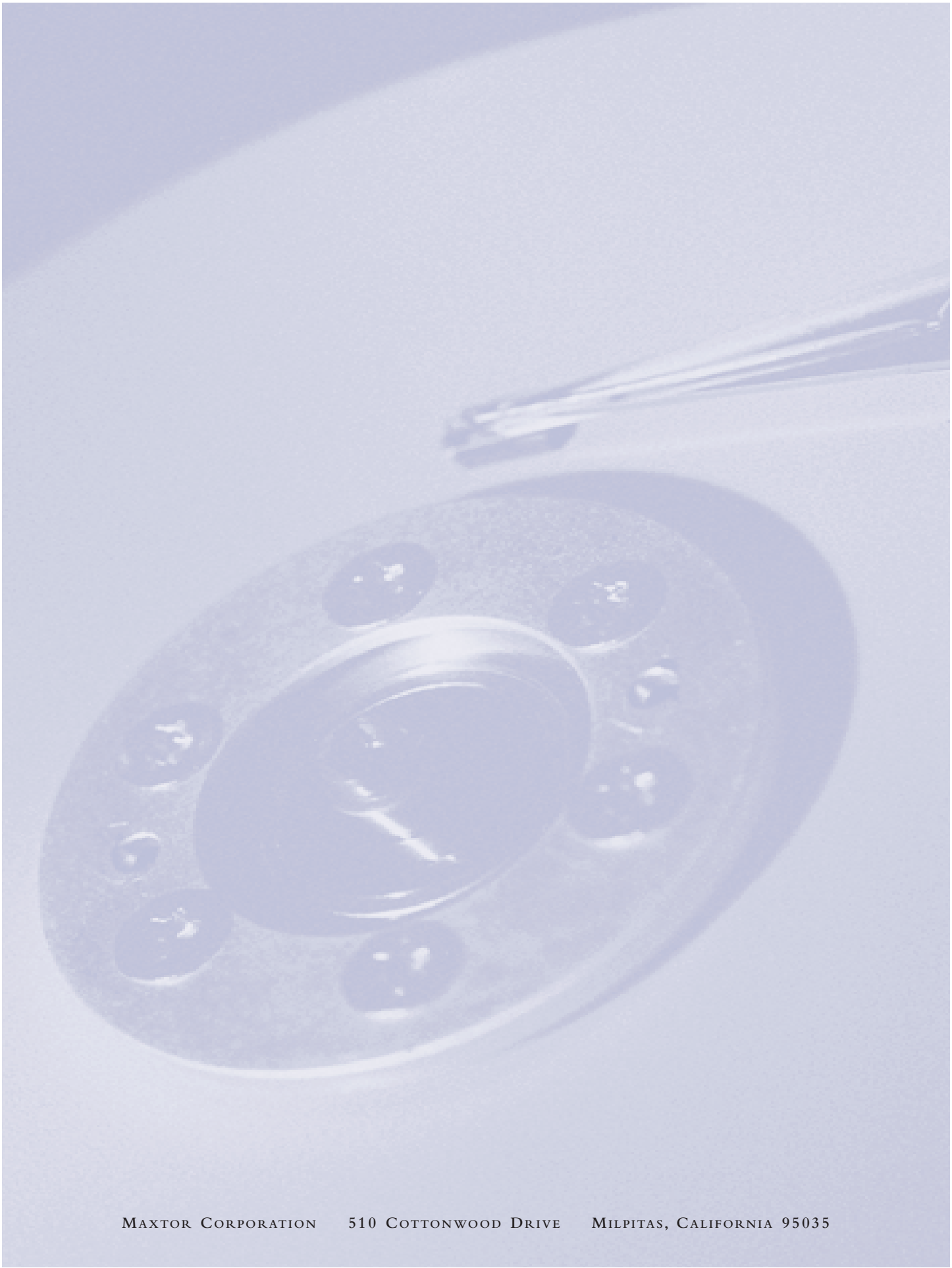
WINDOW MARGIN
The amount of tolerance a read/write system has for transition jitter at a specified error rate level.

WORD
A number of bits, typically a multiple of eight, processed in parallel (in a single operation). Standard word lengths are 8, 16, 32 and 64 bits (1, 2, 4, or 8 bytes).

WRITE
The recording of flux reversals on a magnetic media.

WRITE PRE-COMPENSATION
The intentional time shifting of write data to offset the effects of bit shift in magnetic recording.

WRITE GATE SIGNAL
A digital input signal level which causes the drive circuitry to record (write) data.



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